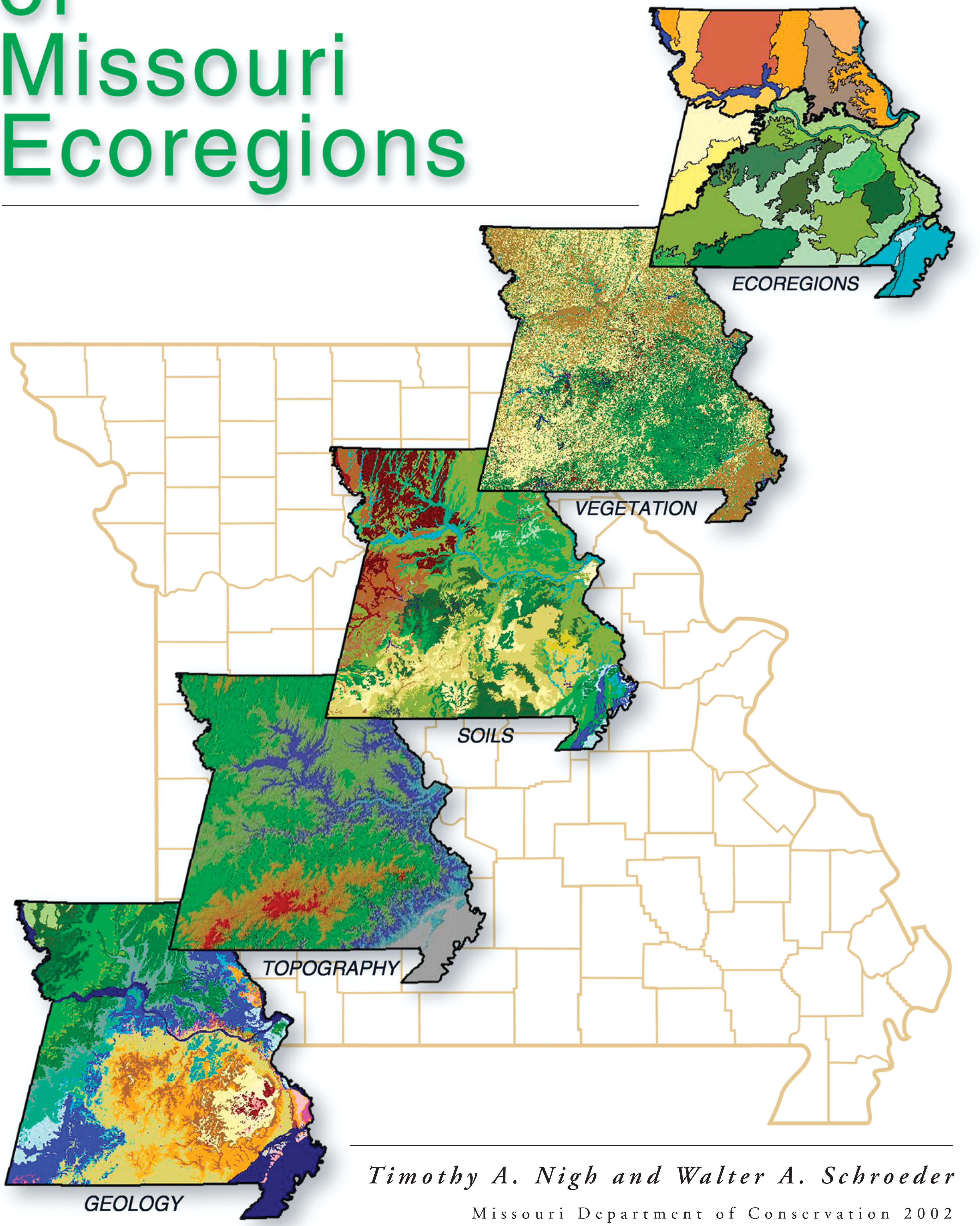
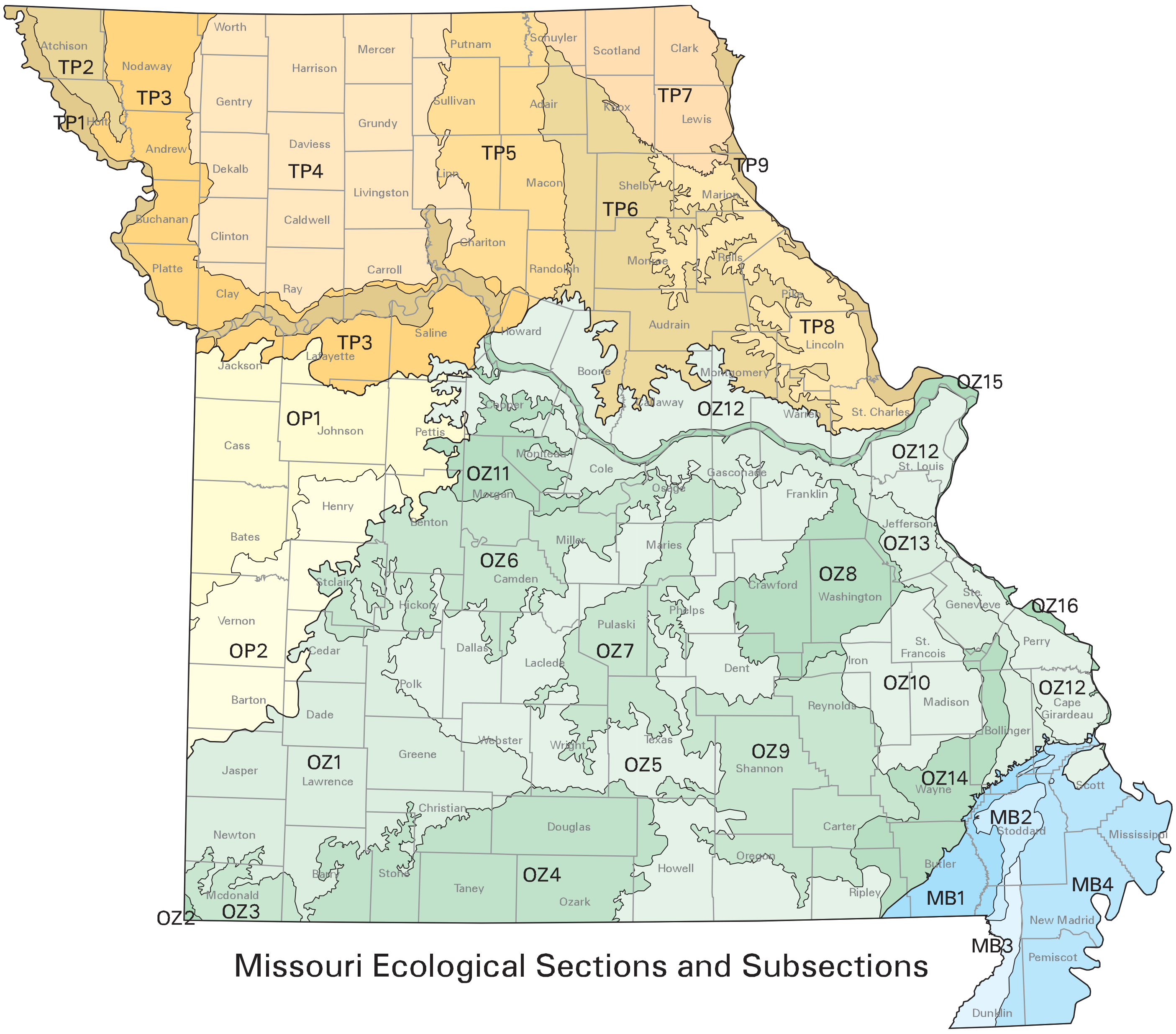
Atlas of Missouri Ecoregions



Timothy A. Nigh and Walter A. Schroeder

Missouri Department of Conservation 2002



Missouri Ecological Sections and Subsections

List of Sections, Subsections and Landtype Associations (LTAs)

Atlas of Missouri Ecoregions

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Missouri Department of Conservation 2002

Abstract

The conservation of Missouri's rich array of native plant and animal species will require the maintenance and enhancement of the native ecosystems they depend on. Regional and landscape ecosystems for Missouri have been derived using the United States Forest Service approach to ecological classification.

An ecological classification system (ECS) is a framework that allows natural resource managers to identify, describe, and map units of land with similar physical and biological characteristics at scales suitable for natural resources planning and management. Once in place, an ECS serves as a basis for an inventory of the number, size, location, and status of native ecosystems. An ECS allows planners and managers to assess the capability of land to produce resources and respond to management. An ECS is also a common communication tool for considering the conservation of multiple resource values.

The Missouri Ecological Classification Project has been working to apply the USFS National Hierarchical Framework of Ecological Units toward ecological classification of lands in Missouri. Under this framework, attributes of climate, landforms, geology, hydrology, soils, and vegetation patterns are utilized at various scales to divide the earth's surface into progressively finer ecological units. The influence of each of these attributes varies, depending upon the scale of application and local significance of a factor. The spatial hierarchy of this system enables users to address resource management issues at national, regional, landscape, or local scales. This enhances our ability to nest local resource management objectives into larger contexts, so that local accomplishments contribute to the overall condition of the landscape or ecoregion.

The Missouri ECS Project has participated in the national effort to develop ecological units through the Subsection level. Landtype Associations have been developed and mapped for Missouri through a locally coordinated effort. Ecological Landtypes (ELTs) and ELT-Phases (ELT-Ps) have been developed for the Current River Hills Subsection by intensive field sampling and analysis.

The purpose of this atlas is to provide maps and descriptions of the 4 ecological Sections, 31 Subsections, and 264 Landtype Associations for Missouri. The atlas is intended to serve as a tool for understanding these ecosystems and as an ecological framework for natural resources inventory, planning, and management.

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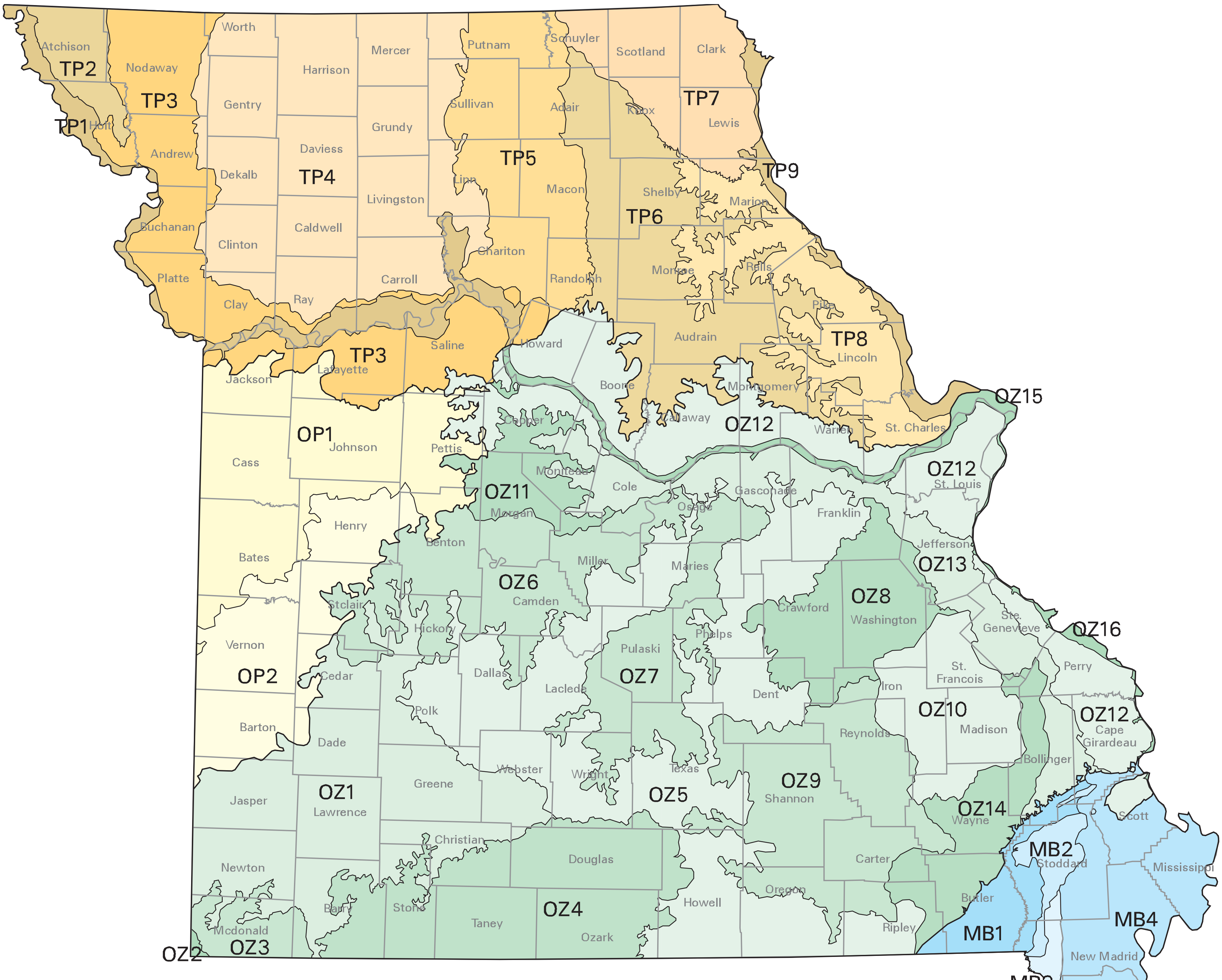

Missouri Ecological Sections and Subsections

(landtype associations listed are not shown on map)

OP Osage Plains Section

OZ Ozark Highlands Section

MB Mississippi River Alluvial Basin Section

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TP Central Dissected Till Plains Section

OP Osage Plains Section

OZ Ozark Highlands Section

MB Mississippi River Alluvial Basin Section

Foreword

In 1995, the Missouri Resource Assessment Partnership (MoRAP) endorsed a proposal to develop an ecological classification system (ECS) for Missouri. The ECS provides an effective framework for natural resources inventory, planning, and management. The MoRAP partners have developed a number of digital data layers over the past six years that are needed to pursue an ECS and to provide for practical applications. Over the past several years, the ECS, in combination with other newly developed data layers, has been effectively applied to regional assessment and planning.

Development of the system truly has been a team effort. We are excited to finally have this atlas documenting and describing the system within Missouri. In addition to the printed atlas, a CD-ROM containing text and map plates, digital coverages, and attribute databases is available.

We are indebted to Dr. Walter Schroeder, Tim Nigh, and their numerous colleagues for many hours of effort that have resulted in this outstanding product: an easily accessible system that will continue to enhance our ability to view and manage resources more holistically at regional and landscape scales.

David D. Diamond
MoRAP Director

Kari J. Craun, USGS
MoRAP Steering Committee Chair

MoRAP Partners

American Bird Conservancy

James River Basin Partnership

Missouri Department of Conservation

Missouri Army National Guard

Missouri Department of Natural Resources

Missouri Department of Transportation

Ozark National Scenic Riverways

U.S. Environmental Protection Agency

USDA/FS Mark Twain National Forest

USDA Natural Resources Conservation Service

United States Fish and Wildlife Service

USGS Columbia Environmental Research Center

USGS Missouri Cooperative Fish and Wildlife Research Unit

USGS Mid-Continent Mapping Center

University of Missouri–Columbia

World Wildlife Fund

Acknowledgments

The Missouri Ecological Classification System Project is an interagency-sponsored project conducted under the auspices of the Missouri Resource Assessment Partnership (MoRAP). While funding was provided by the Missouri Department of Conservation, USDA North Central Forest Experiment Station, and the Mark Twain National Forest, contributions of staff and in-kind services was provided by all of the MoRAP partners. MoRAP acted diligently as the project administrator and the forum for interagency coordination.

Development and applications of multiple digitally accessible, spatial data layers were supported by five Geographic Information System labs. The Geographic Resources Center (University of Missouri–Columbia [UMC] Department of Geography), along with James Harlan and Timothy Haithcoat, supported early efforts to map sections and subsections for the national effort. David Diamond and Diane True from MoRAP provided invaluable information and advice throughout the duration of this project. The Missouri Department of Conservation GIS lab, along with Tony Spicci and Kevin Borisenko, were consistently supportive in providing data layers and technical advice. The Center for Agricultural Research and Environmental Sciences (CARES at UMC) and their staff members Chris Barnett and Bryan Mayhan provided valuable digital soils information. Finally, the ECS project shared a GIS lab with the USGS-Northern Prairie Research Center on the UMC campus. Fred Young and Bill Pauls from the National Resources Conservation Service wrote the soil descriptions. **John Krstansky** provided all GIS and cartographic support throughout the mapping of Landtype Associations and the production of the atlas.

Development and mapping of ecological units was overseen by an interagency project team. Core team members participated consistently throughout the process, while extended team members were consulted as needed. Together these people provided the expertise and camaraderie to make this project possible. They are listed below.

Development of the *Atlas of Missouri Ecoregions* has been a team effort. A hearty thanks to all those who have participated. The atlas is something we can all be proud of.

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Introduction

PURPOSE

Missouri is a beautiful and diverse state. Located near the center of the North American continent at the confluence of our nation's largest rivers, Missouri is home to more than five thousand species of plants and more than twenty thousand animals. Missouri's biodiversity contains representatives from adjacent biomes, as well as species found only here. Conservation of our native flora and fauna will require the maintenance and restoration of the native ecosystems that support them.

In order to conserve our natural heritage and accommodate the diversity of demands being placed on our natural resources, natural resource planning and management is shifting from an emphasis on individual species or products toward the management of entire ecosystems. An ecosystem—defined simply as a community of living organisms interacting with each other and the physical environment—is a level that allows humans to more easily recognize the interrelationships between individual physical and biological resources, integrate their individual viewpoints and needs, and predict the capability of a unit of land to provide a variety of compatible outputs.

The purpose of this atlas is to provide a framework for recognizing Missouri's ecosystems at regional and landscape scales. It provides maps and descriptions of useful and functional units of land that have characteristic patterns in their biological and physical attributes. We hope this system will become a common communication tool that facilitates planning, management, and research at an ecosystem level. Carry this atlas with you as you travel, and use it to gain a better understanding and a *sense of place* about the territory you live in.

CONCEPTUAL APPROACH

For centuries, geographers worked with the idea that the earth's surface could be divided into natural regions having similar environmental characteristics throughout. It is now widely recognized that clearly defined natural or ecological regions do not inherently exist. Rather they are constructs of the human mind that await to be discovered, described, analyzed, and mapped according to the purposes and criteria we define. Numerous divisions and maps of the earth's surface have been constructed using only one or a few environmental components. Thus, there are maps of soil regions, physiographic regions, climate regions, lithologic regions, tectonic regions, biogeographic regions, plant (phytogeographic) regions, and animal (zoogeographic) regions.

More recently, the desire to take a more holistic or ecological approach to natural resource management has led to the development of multifactor land classification systems that attempt to integrate numerous physical and biological components into the recognition and mapping of natural or ecological regions. These efforts have been enhanced by the advent of Geographic Information Systems (GIS) that allow us to view and integrate any number of layers or maps. Despite the utility of this technology, natural or ecological regions remain a human construct, and no single, universal set of natural or ecological regions will satisfy all purposes.

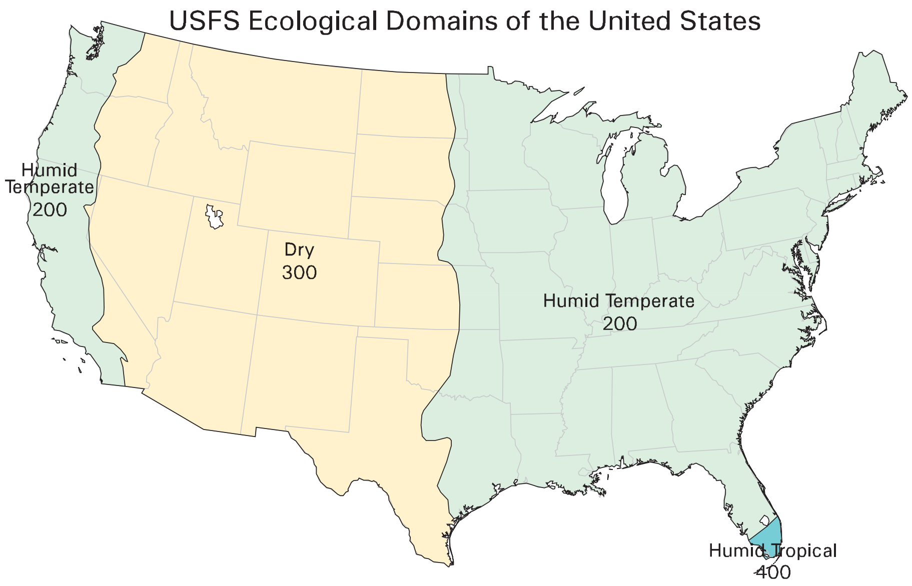
With these caveats in mind and after careful consideration of numerous alternatives, a working group with members from numerous state, federal, and private natural resource organizations determined that application of the USFS National Hierarchical Framework of Ecological Units (Avers et al., 1994) toward the identification and mapping of ecological units of land in Missouri would be valuable (Nigh and Amelon, 1995). This ecological classification system (ECS) is spatially hierarchical; that is, it breaks the land into a nested system of units from broad ecoregions to subregions, through landscapes to local sites. Thus an ECS facilitates planning and management at multiple spatial scales from regional through local to the individual project level. In addition, ecological units in Missouri are nested into a *national* land classification system. Being part of a national system gives Missouri a broader ecological context and fosters communication with federal agencies and adjacent states. The system integrates a wide variety of physical and biological factors into the identification of ecological units and identifies major differentiating criteria for delineation of units at all levels in the hierarchy. Consequently, multiple ecosystem components are integrated into a single system, and consistent standards exist for application of ECS across all states. These criteria are applied to the development of a mappable framework of land units. These maps and their descriptions are tools for identifying and prioritizing natural resource outputs most suitable for a given land unit and help land managers predict outcomes of various management practices. Additionally, the system is designed to be dynamic and flexible, so that it can change as new information becomes available and users of the system provide feedback. Thus, this is the first approximation of a system that will evolve through time.

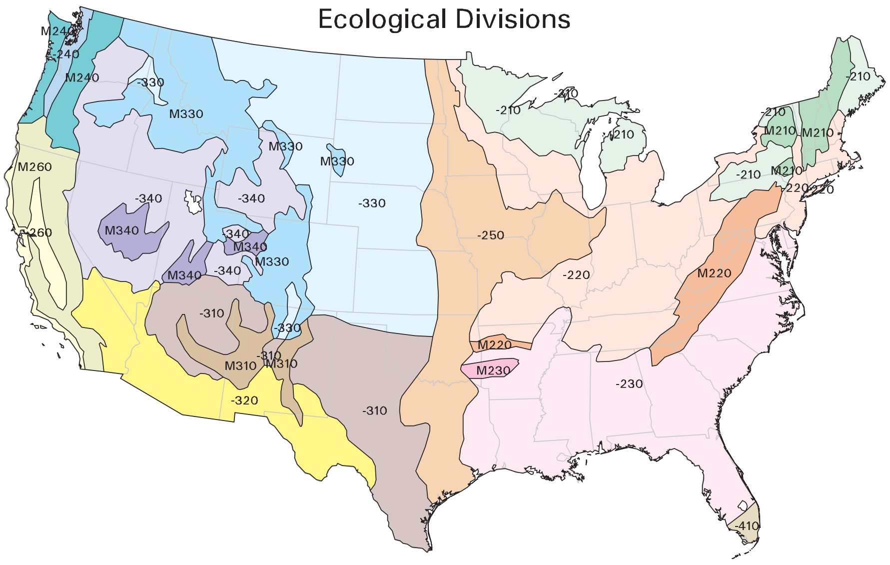
THE USDA FOREST SERVICE HIERARCHY OF ECOLOGICAL UNITS

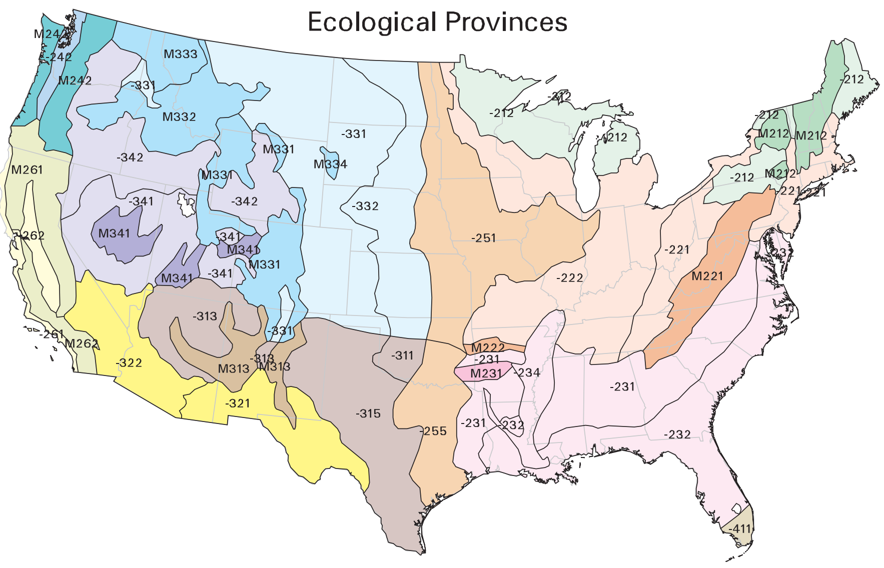
The national framework consists of a nested hierarchy of eight levels of classification and geographic generalization. At the higher, most generalized levels, conti-

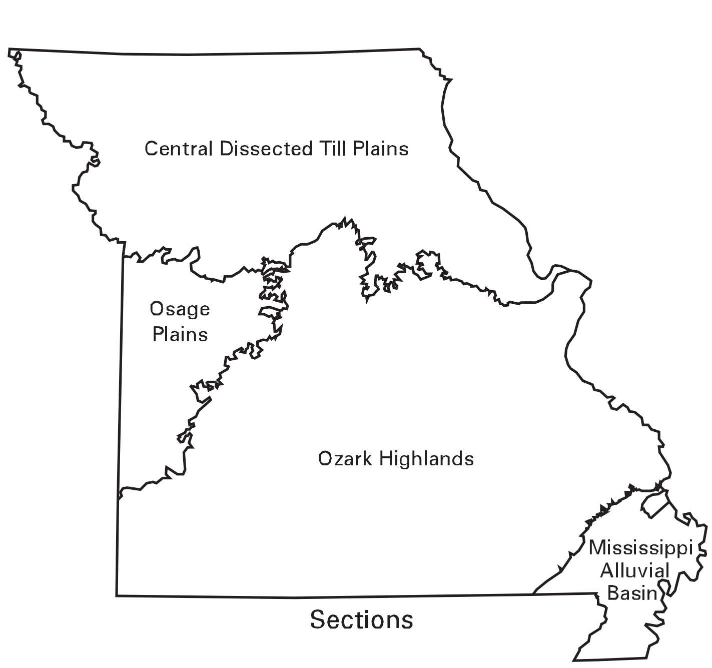
TABLE 1. NATIONAL HIERARCHICAL FRAMEWORK FOR ECOLOGICAL CLASSIFICATION (Avers et al., 1993) AND APPLICATION TO MISSOURI

Scale	Ecological Units	Size	Major Differentiating Criteria	Example Missouri and Current RiverHills Types
Ecoregion	Domain	Subcontinental 1,000,000 sq. mi.	Continental and Regional Climate Zones Broad Soil and Vegetation Lifeform patterns	Humid Temperature Domain
	Division	Multiple State 100,000 sq. mi.		Hot Continental Division
	Province	Multiple State 10,000 sq. mi.		Eastern Broadleaf Forest Province
Subregion	Section	Regions 1000 sq. mi.	Regional and Subregional Ppt. and Temp. Geomorphology Major Soil Great Groups Potential Vegetation Formations	Ozark Highlands Section
	Subsection	Subregions 10-100s sq. mi.		Current River Hills Subsection
Landscape	Landtype Association (LTA)	Landscape 1000s acres to 10s sq. mi.	Local Climate Landform/Topography Geologic Parent Materials Soil Associations Potential Vegetation Alliances	Current and Black River Breaks LTAs Jacks Fork and Eleven Point Breaks LTAs Current–Eleven Point Dissected Plains LTA Eminence Igneous Knobs LTA
Land Unit	Landtype (ELT)	Site 1–100s acres	Landform/Topographic Position Geologic Parent Materials Soil Series Potential Vegetation Association	Roubidoux/Upper Gasconade Summits ELT Lower Gasconade Bench ELT Active River Channel ELT
	Landtype Phase (ELT-P)	Site <100 acres		Rocky, Ultic RO/UG Summits ELT-P Ultic Lower Gasconade Bench ELT-P Barren/Herb Gravel Bar ELT-P









nental climate, broad patterns of soils, and natural vegetation are most important in differentiating *domains, divisions,* and *provinces.* At intermediate levels, lithology, topography, geomorphology, regional soils, and regional potential vegetation are most important in delineating *sections* and *subsections.* At the lower levels, the most important factors are local variations in topography, parent materials, soil types, and vegetation communities, which define *landscapes* and *site-specific levels.* Thus, the problem of how to weight the various components of the environment is addressed by bringing in different ones at different levels of the hierarchy. A more complete discussion of the system is in the National Hierarchical Framework of Ecological Units (Avers et al., 1994).

The classification system has both a terminology and a numerical code for each unit. The terminology reflects what the distinguishing criteria are for that level. For example, at the province level, "Eastern Broadleaf Forest (Continental)" indicates geographic location, climate, and broad vegetation formations as criteria. At the section and subsection levels, terminology consists of a geographical identifier ("Current River") and a topographic descriptor ("Hills"). At the landtype association level, terminology consists of a geographical identifier ("Current and Black River"), a vegetation descriptor ("Oak Forest"), and a topographic descriptor ("Breaks").

The highest levels of the system—*domain, division,* and *province*—are levels of great generalization useful for national planning and assessment. All of Missouri lies within the *Humid Temperate Domain* (code number 200). Missouri includes portions of three *divisions: Hot Continental* (220), *Subtropical* (230), and *Prairie* (250). Each of these three divisions is represented in Missouri by a single *Province,* respectively, *Eastern Broadleaf Forest (continental)* (222), *Lower Mississippi Riverine Forest* (234), and *Prairie Parkland (Temperate)* (251). The three highest units were determined at the national level with national perspectives.

The intermediate levels of the classification system are the *section* and *subsection.* They are useful for statewide and regional assessment and planning. These units were determined by persons working at the state level, in cooperation with their counterparts in adjacent states. Missouri has four *sections* that have been recognized as distinct biogeographic regions for over a century. They are the *Ozark Highlands* (222A), *Mississippi Alluvial Basin* (234A), *Central Dissected Till Plains* (251C), and *Osage Plains* (251E). Criteria used to establish sections are geomorphology (land

USFS Ecological Domains, Divisions, and Provinces

200 HUMID TEMPERATE DOMAIN

-210 Warm Continental Division
-212 Laurentian Mixed Forest Province

M210 Warm Continental Regime Mountains
M212 Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow Province

-220 Hot Continental Division
-221 Eastern Broadleaf Forest (Oceanic) Province
-222 Eastern Broadleaf Forest (Continental) Province

M220 Hot Continental Regime Mountains
M221 Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow Province
M222 Ozark Broadleaf Forest - Meadow Province

-230 Subtropical Division
-231 Southeastern Mixed Forest Province
-232 Outer Coastal Plain Mixed Forest Province
-234 Lower Mississippi Riverine Forest Province

M230 Subtropical Regime Mountains
M231 Ouachita Mixed Forest - Meadow Province

-240 Marine Division
-242 Pacific Lowland Mixed Forest Province

M240 Marine Regime Mountains Redwood Forest Division
M242 Cascade Mixed Forest-Coniferous Forest-Alpine Meadow Province

-250 Prairie Division
-251 Prairie Parkland (Temperate) Province
-255 Prairie Parkland (Subtropical) Province

-260 Mediterranean Division
-261 California Coastal Chapparral Forest and Shrub Province
-262 California Dry Steppe Province

M260 Mediterranean Regime Mountains
M261 Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow Province
M262 California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow Province

300 DRY DOMAIN

-310 Tropical/Subtropical Steppe Division
-311 Great Plains Steppe and Shrub Province
-313 Colorado Plateau Semi-Desert Province
-315 Southwest Plateau and Plains Dry Steppe and Shrub Province

M310 Tropical/Subtropical Regime Mountains
M313 Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province

-320 Tropical/Subtropical Desert Division
-321 Chihuahuan Semi-Desert Province
-322 American Semi-Desert and Desert Province

-330 Temperate Steppe Division
-331 Great Plains-Palouse Dry Steppe Province
-332 Great Plains Steppe Province

M330 Temperate Steppe Regime Mountains
M331 Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province
M332 Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province
M333 Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province
M334 Black Hills Coniferous Forest Province

-340 Temperate Desert Division
-341 Intermountain Semi-Desert and Desert Province
-342 Intermountain Semi-Desert Province

M340 Temperate Desert Regime Mountains
M341 Nevada-Utah Mountains-Semi-Desert-Coniferous Forest-Alpine Meadow Province

400 HUMID TROPICAL DOMAIN

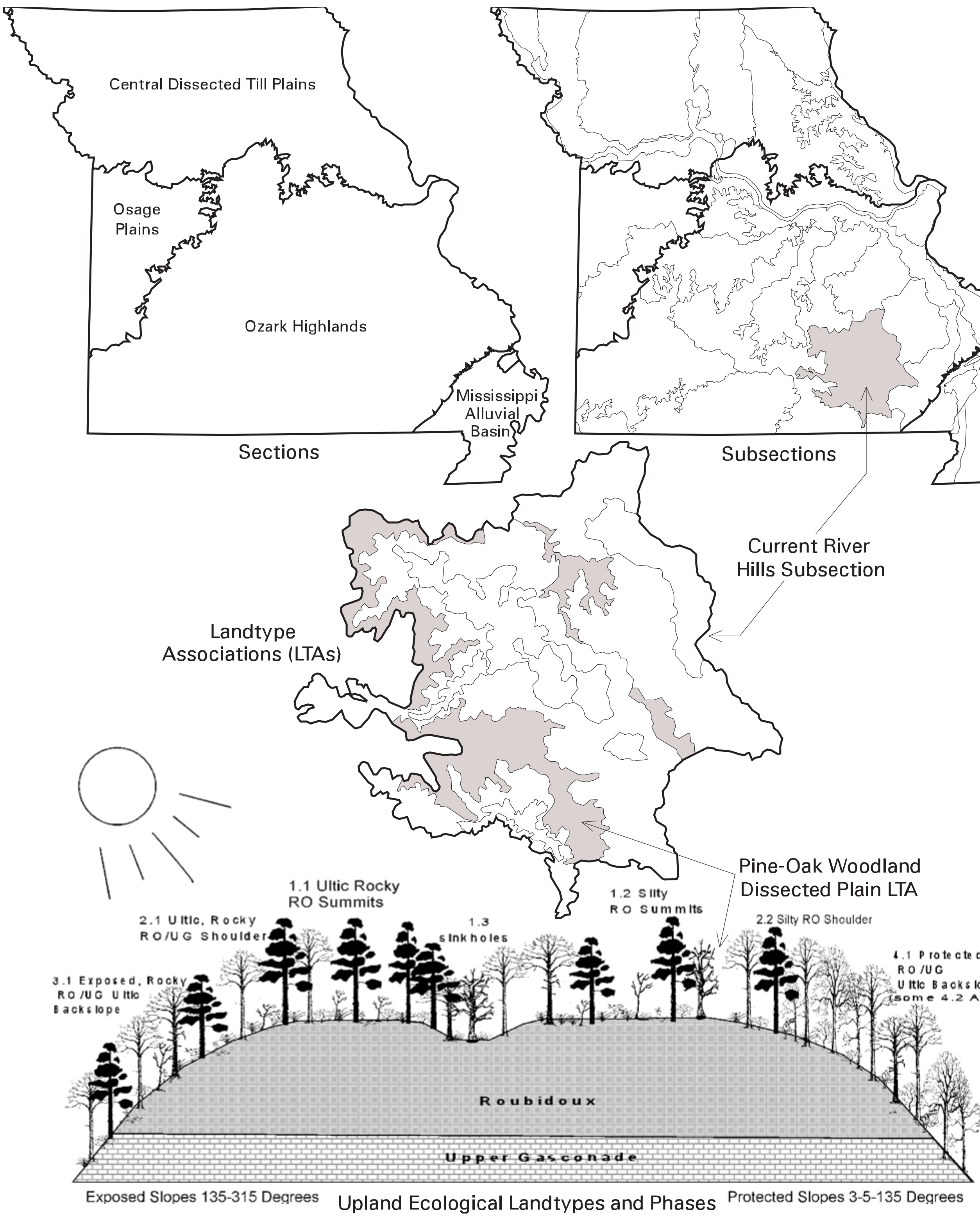
-410 Savanna Division
-411 Everglades Province

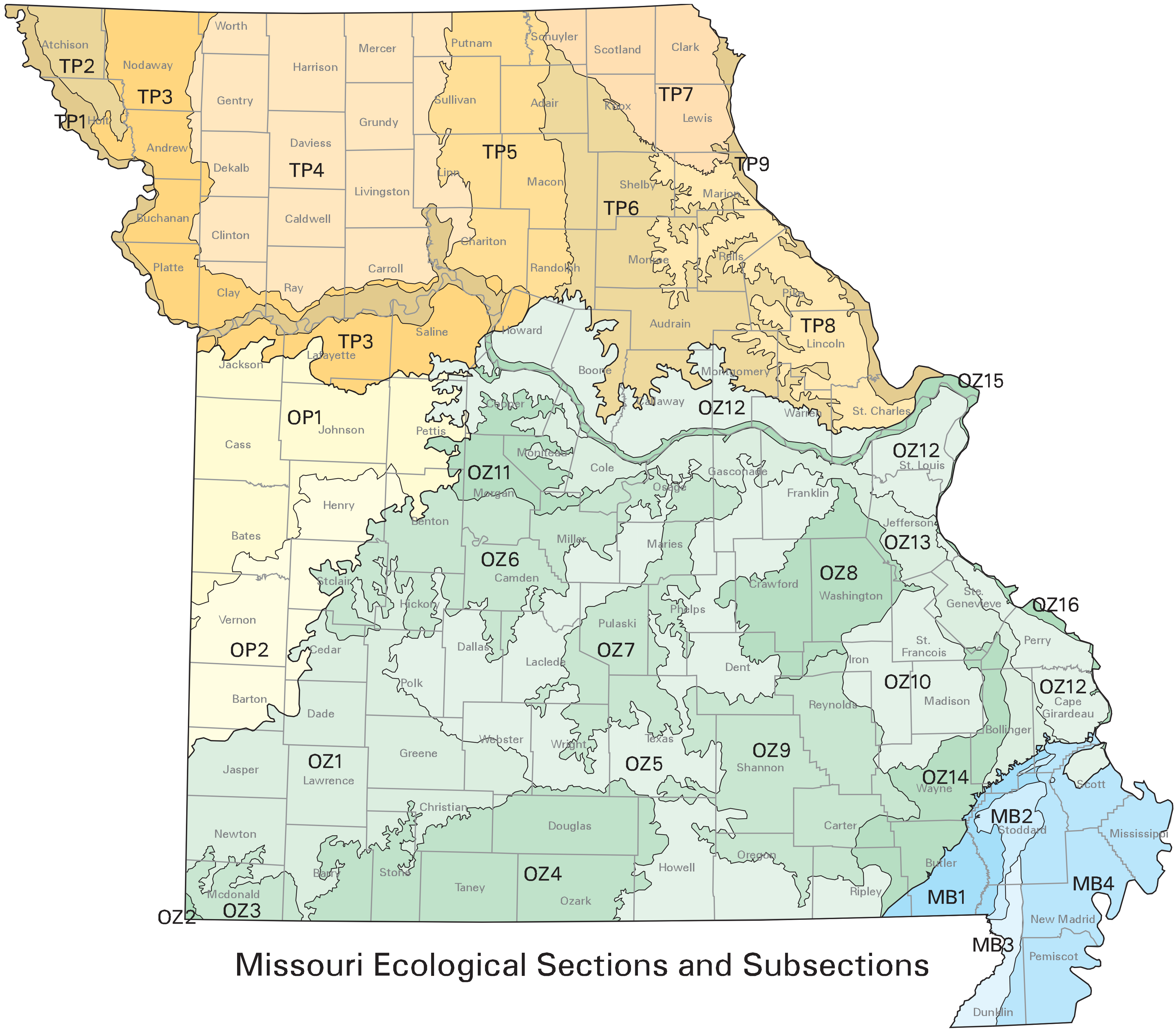
form, relative relief, lithology, structure, and geomorphic process), potential vegetation, and major soil groups. *Sections* are subdivided into *subsections,* which average approximately 2,000–3,000 square miles or from three to five counties in Missouri. There are a total of thirty-one subsections in Missouri, of which the Ozark Highlands section accounts for sixteen. Some of these subsections primarily lie in adjacent states, with only small portions of them extending into Missouri. In general, the same criteria that are used to establish sections are used to establish subsections, although at a higher resolution *(see map on page 4).*

The lower levels of the hierarchical classification consist of the landtype association (LTA), ecological landtype (ELT), and ecological landtype phase (ELT-P). These levels are appropriate for local planning and assessment, such as watersheds, counties, ranger districts, conservation areas, and even site and landownership tract planning. LTAs and ELTs are based on more local patterns in topography, geologic parent materials, soil types, and vegetation communities. The distinctive character of the LTAs influences the distribution of natural resources, and thus the management challenges and opportunities, at a landscape scale. While LTAs are from tens to hundreds of square miles in size, the lowest level, ELT-P, identifies ecosystem units as small as a few acres. They have relevance at a site or stand level. As of 2002, mapping of LTAs has been completed for Missouri and is introduced in this atlas. However, only small portions of the state have been classified and mapped at the ELT and ELT-P levels. State and federal agencies can provide the reader with updated information on the status of classification and mapping of these levels in Missouri.

The numerical code developed for the national framework has been replaced by a code more suitable for Missouri. This makes it possible to use letters for sections (OZ), numbers for subsections (OZ1), and small letters for LTAs (OZ1a) for easier communication and map labeling of the units relevant to our state.

While the rationale and structure of the framework is unlikely to change in the foreseeable future, the identification of specific units and their boundaries certainly will. The hierarchical system has been built from the top down, a procedure necessitated by the lack of detailed information and understanding at local levels. As more information becomes available at lower levels, modifications may have to be made at progressively higher levels. This is most clearly seen with boundaries. The more generalized boundaries drawn at the subsection level on the basis of more geographically generalized information will have to be refined as more detailed mapping is done at the LTA and lower levels. Higher-resolution classification and mapping will help make the earlier boundaries, drawn with lower-resolution information, factually more accurate and geographically more precise.





Missouri Ecological Sections and Subsections

MB Mississippi River Alluvial Basin Section

MB1 Black River Alluvial Plain Subsection
MB2 Crowley's Ridge Subsection
MB3 St. Francis River Alluvial Plain Subsection
MB4 Mississippi River Alluvial Plain Subsection

OP Osage Plains Section

OP1 Scarped Osage Plains Subsection
OP2 Cherokee Plains Subsection

OZ Ozark Highlands Section

OZ1 Springfield Plain Subsection
OZ2 Springfield Plateau Subsection
OZ3 Elk River Hills Subsection
OZ4 White River Hills Subsection
OZ5 Central Plateau Subsection
OZ6 Osage River Hills Subsection
OZ7 Gasconade River Hills Subsection
OZ8 Meramec River Hills Subsection
OZ9 Current River Hills Subsection
OZ10 St. Francois Knobs and Basins Subsection
OZ11 Prairie Ozark Border Subsection
OZ12 Outer Ozark Border Subsection
OZ13 Inner Ozark Border Subsection
OZ14 Black River Ozark Border Subsection
OZ15 Missouri River Alluvial Plain Subsection
OZ16 Mississippi River Alluvial Plain Subsection

TP Central Dissected Till Plains Section

TP1 Missouri River Alluvial Plain Subsection
TP2 Deep Loess Hills Subsection
TP3 Loess Hills Subsection
TP4 Grand River Hills Subsection
TP5 Chariton River Hills Subsection
TP6 Claypan Till Plains Subsection
TP7 Wyaconda River Dissected Till Plains Subsection
TP8 Mississippi River Hills Subsection
TP9 Mississippi River Alluvial Plain Subsection

RELATIONSHIPS TO OTHER NATURAL OR REGIONAL ECOSYSTEM MAPS

The Natural Divisions of Missouri. In 1980, Thom and Wilson established the Natural Divisions of Missouri in order to give guidance and statewide geographic coherence to the protection of designated Natural Areas and listed Rare or Endangered Species. The system has gained widespread use over the past two decades. While similar to the Missouri ECS, there are some important differences.

The Thom and Wilson system preserved the four major "natural divisions" of Missouri that had been recognized since the nineteenth century: the Ozarks, the Glaciated Plains, the unglaciated Osage Plains, and the southeastern Mississippi Lowlands. These four regions are largely determined by landform (topography), rock type (lithology), and surface material. A new concept for natural regions in Missouri that Thom and Wilson introduced was the separation of the channels and alluvial plains of the Mississippi and Missouri Rivers into their own natural division, the Big Rivers. They also pulled the Ozark Border Division out as distinct from the Ozarks. The subdivision of these divisions into eighteen sections is heavily influenced by drainage basins; many section boundaries are drawn along drainage divides. Thus, the hydrologic organization of the landscape is important in the determination of this early set of natural regions. The text that accompanies the map, which presents the rationale and distinguishing characteristics of each division, is heavily weighted in terms of distinctive plant, animal, and fish species, and natural communities, which reflects the perspectives of the authors and the ultimate use of the system in protection of natural areas and rare species.

Many of the sections in Thom and Wilson are the same in concept to the subsections in this ECS. Some differences are related to our current ability to add precision to a boundary using GIS technology. Other differences between Thom and Wilson's sections and the current ECS subsections are based mainly on our reliance on topography, geology, soil, and vegetation patterns, rather than watersheds, in their delineation. This is true especially in the Ozarks, where the recognition of the Central Plateau Subsection encompasses many watershed divides. Finally, the natural divisions and their sections stop at the Missouri state line, with no formal linkages established outside of the state.

The Ecological Classification System of the Environmental Protection Agency. A separate ecological classification and mapping system has been developed under the aegis of the Environmental Protection Agency (EPA) (Omernik, 1987; Omernik, 1995). It has also been developed with national standards and a uniform procedure for all states, and it is also hierarchical with four levels of generalization. EPA Ecoregions are also relevant to integrated ecosystem management, but more specifically they help in the development of biological criteria and water quality standards and management goals for non-point-source pollution (Chapman et al., 2002). The EPA approach to identification of ecological regions is to analyze patterns of biotic and abiotic components (geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology) that reflect differences in ecosystem quality and integrity. However, instead of the various components being weighted differently at the various levels of the hierarchy, in the EPA system the relative importance of each component varies from one ecological region to another regardless of the hierarchical level. That is, the most distinguishing features of each ecosystem are identified at each level of the hierarchy (Omernik 1995; Griffith et al., 1994). The ecological classification and mapping units developed by the EPA system for Missouri were published in 2002 as a map at 1:1,800,000 and an accompanying table of characteristics (Chapman et al., 2002). Participation by members of the Missouri ECS team in this effort resulted in most of the level IV units of the EPA system being coincident with subsections of the Missouri ECS. However, Level III units are substantially different than USFS sections. Many of the differences appear to be related to a heavy reliance on current land-cover patterns by the EPA mappers.

The Ecological Land Classification System of the Mark Twain National Forest. Miller (1979) developed a classification system of Mark Twain National Forest (MTNF) lands based on the USDA Forest Service Hierarchy. Sections and subsections followed Thom and Wilson (1981) and did not link to adjacent states. LTAs and ELTs were developed for MTNF lands only. Consequently, these units were derived by looking only at the range of character of lands within their ownership. This resulted in somewhat different criteria for mapping LTAs, and thus some differences with statewide LTAs are seen. For example, because MTNF lands do not occupy the steepest lands on the Current or Black Rivers, they miss the extreme "breaks" landform. Therefore their "breaks" are similar to "hills" in the Missouri ECS where breaks are delineated for the most rugged lands only. ELTs were developed with a different set of landforms and relied heavily on soil maps and subjective application of vegetation classification. The Missouri ECS pilot ELTs that were developed for the Current River Hills Subsection relied on field sampling of soil and vegetation data among different landforms and geologic parent materials, resulting in tighter biophysical relationships that are able to be modeled in GIS. Despite these differences, the MTNF system has had a history of effective application on the forest. One might consider the Missouri ECS as a statewide extension of the earlier MTNF effort. It is hoped that the Missouri ECS will provide a broader context for MTNF lands.

METHODS OF DETERMINING MISSOURI SECTIONS, SUBSECTIONS, AND LANDTYPE ASSOCIATIONS

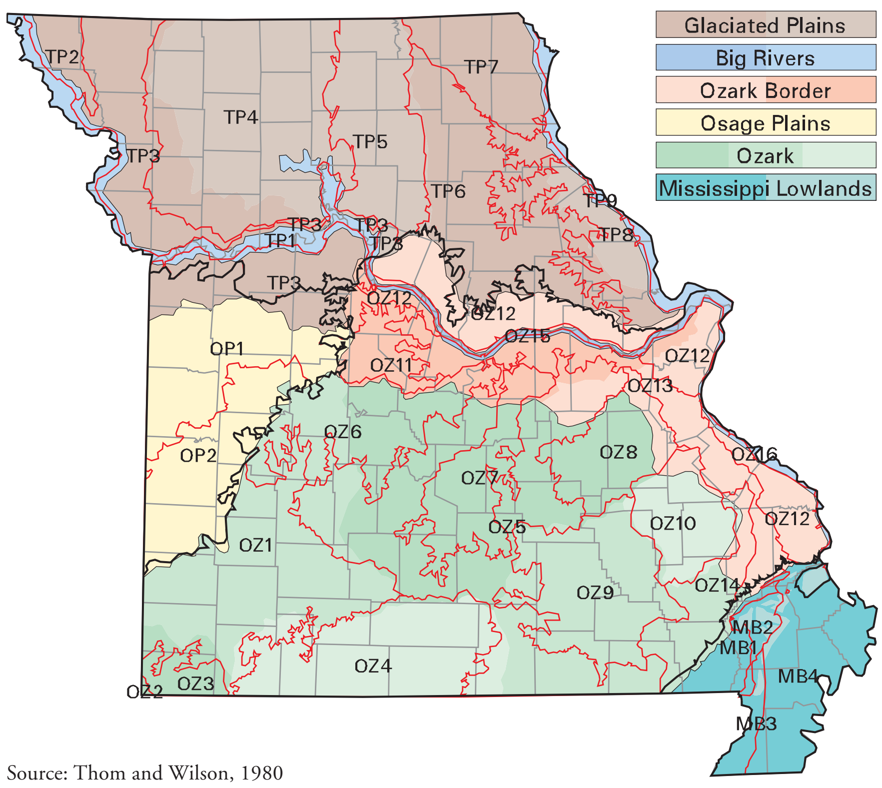
At the beginning of the Missouri ECS Project, an interagency team with experts from most state, federal, and private natural resource organizations was assembled to oversee the project and periodically review products. In addition to principal, core members, many other specialists were consulted as needed in the process. The Missouri sections and subsections were determined and mapped by the interagency ECS Team during 1993–1994. During this process and later we consulted with adjacent states and coordinated cross-state boundary matching. We also reviewed the ecoregions developed in other states (Foti, 1974; Schwegman, n.d.; Pell, 1983; Prior, 1991; Griffith et al., 1994; Hole, 1994; Woods and Omernik, 1996; Griffith et al., 1998; Pater et al., 1998; Bryce et al., 1998; Woods et al., 1999; Chapman et al., 2000; and Omernik et al., 2000). Printed maps, digital coverages, and descriptive information were provided to the USDA Forest Service Eastern Region ECOMAP Team for inclusion in two national publications and a CD-ROM (McNabb and Avers, 1994; Keys et al., 1995).

The LTAs were mapped systematically, subsection by subsection, during 1995–1998. Only Missouri portions of each subsection were considered for this mapping effort. Because we used some higher-resolution source data for the LTA mapping, subsection boundaries were refined by this process. In addition, several changes not reflected in the national subsection documentation were created during LTA mapping. These were passed along to the national effort for future revisions.

Throughout the process, we used published and unpublished maps and other references listed in the bibliography, consulted with others knowledgeable about specific topics and regions of the state, and benefited from several decades of fieldwork and personal knowledge with the physiography and biogeography of the state.

We worked under guidelines issued by the Forest Service for the establishment of sections, subsections, and LTAs in all states. Among these guidelines were considerations of reasonable compactness and contiguity of mapped areas and maximum and minimum areal limitations (not too large, not too small). Guidelines directed that sections and subsections should be based primarily on physical characteristics (lithology, relief, slope, elevation, and geomorphic process), potential natural vegetation, and soils. All other environmental components could be considered where appropriate. Different components were used as the distinguishing characteristic in some subsections and LTAs. For example, surficial material (loess) and soils took primacy in identifying the subsections of northwestern Missouri, karst distinguishes several Ozark subsections and LTAs, and fluvial processes distinguish the Missouri and Mississippi River subsections. Finally, we retained long-established regions and their terminology, where appropriate, to avoid creating radically different regions and boundaries and introducing terminology that differed from that used vernacularly in Missouri. The guidelines also recommended a topical outline for the nomenclature of subsections and LTAs, which we followed.

Natural Divisions, Sections,
and Ecological subsections of Missouri



Source: Thom and Wilson, 1980

The mapping process was an iterative one of visual integration of numerous physical and biological maps, along with expert input from written and verbal sources. We often started with existing regionalizations of the state, especially Schroeder Landform Regions (in progress) and a Missouri General Soils Map (Allgood and Persinger, 1979), and digital elevation models as a way of initiating our understanding of the physical setting of potential ecoregions. Often, obvious differences in landforms would be related to coarse patterns in geology and soils, leading to an initial set of lines. These lines were then superimposed on other layers, such as higher resolution soils, topography, and historic and current vegetation, and adjusted accordingly. Map units were then digitized and printed on top of relevant diagnostic layers for review by team members. Subsection mapping was done at 1:500,000 with contours from USGS quadrangles at 1:250,000 as a backdrop. LTA mapping was done at 1:100,000 with contours from USGS quadrangles at 1:100,000 as a locational backdrop. All line work was evaluated by team members as the iterative process proceeded until consensus was reached. For LTAs, ground and aerial field reconnaissance, as well as consultation with local experts, was carried out to further evaluate and adjust the lines.

Principal maps included landform regions (Schroeder, n.d.; McBride, 1977), land-resource regions (USDA-SCS, 1981), digital elevation models (60m DEMs derived from 1:100,000 USGS contours), topographic quadrangles (1:250,000 and 1:100,000), bedrock geology (Anderson, 1979; Pratt et al., 1992; and Hall, 1963), soils (Krusekopf, 1966; Allgood and Persinger, 1979; Scrivner et al., 1975; and USDA-STATSGO, 1994), surficial geology (Whitfield, 1982), potential natural vegetation (Küchler, 1964, 1985), presettlement prairie (Schroeder 1981a, 1981b), forest cover (Giessman et al., 1986), and current land cover (MoRAP Land Cover Project). Individual county soil surveys, while not digital, were important in LTA delineation. Other map sources used in delineations and interpretations included quaternary geology (Richmond and Fullerton, 1991; Richmond et al., 1991; and Richmond and Weide, 1993), karst and losing streams (Schroeder, 1982), loess (Ext. Pub. C823), drainage basins (USGS 8- and 11-digit Hydrologic Units), groundwater, climate, and distributions of some key species (Liming, 1946; Batek, 1994), and satellite imagery of the state. Some of these maps were digitized especially for this ecoregion project. We also consulted previous maps of natural regions of the state (Marbut, 1896; Emerson, 1912; Sauer, 1920; Fenneman, 1931, 1938a, 1938b; Schottenloher, 1936; Cozzens, 1937, 1939; Collier, 1955; Hammond, 1958, 1964; Thornbury, 1965; and Omernik, 1987).

For descriptive purposes, we used hydrologic and climatological data as well as databases for rare and endangered species, natural areas, and public lands. We used the national vegetation classification system developed by The Nature Conservancy (TNC) (Faber-Langedoen, 2001) and the 2002 revision of Missouri Terrestrial Natural Communities (Nelson et al., in progress) to describe historic and current vegetation. A comparison of the natural community names used in this atlas with TNC and Missouri Terrestrial Natural Communities is in the appendix.

Interagency coordination and funding allocations were carried out in conjunction with the Missouri Resource Assessment Partnership (MoRAP), an interagency consortium to develop and apply spatial information toward natural resource conservation in Missouri. The section and subsection portion of the project was headquartered in the Department of Geography and the Geographic Resources Center of the University of Missouri–Columbia. LTA work was headquartered at the Missouri ECS project lab in the School of Natural Resources at UMC. Funding for the project was received from the Missouri Department of Conservation, the Mark Twain National Forest, and the North Central Forest Experiment Station.

HOW TO USE THE ATLAS AND ALLIED DATABASES

This atlas is designed to introduce the user to the sections, subsections, and landtype associations in Missouri through the use of maps and descriptive text. It has been formatted so that it can rest on the front seat of a vehicle, allowing the user to trace his routes within the state. The back cover has a template for locating the map plates and text pertinent to the user's location. The Overview of Missouri presents maps and descriptions of most statewide layers used in this classification effort. Following that are the ecological sections; each begins with an overall description of the ecoregion and how it is divided into subsections and LTAs. These are followed by standardized descriptions of each subsection, including tabular descriptions of the LTAs. A guide to the descriptions is located on page 7. Map plates of the subsections and LTAs in each section are located at the end of each section. The location of corresponding maps is identified on the title page for each subsection and on the LTA tables; the location of descriptive text is identified on each map. Links to the location of adjacent map plates are printed on each edge of each plate.

A CD-ROM with the atlas's text and figures, as well as coverages of the ecological units and diagnostic layers and databases associated with each LTA, is available from the Missouri Department of Conservation ECS Project (P.O. Box 180, Jefferson City, MO 65102). A multicolor wall map of the ecological units is also available.

The Central Dissected Till Plains is now a mosaic of cropland, pasture and second growth woodlands.

Paul Childress

A Guide to Subsection and LTA Descriptions

The subsection and LTA descriptions follow a standard format. The headings, their content, and the principle sources of information are described below.

GENERAL DESCRIPTION

A capsule summary of the physical and biological characteristics of the subsection, focusing on those characteristics that distinguish it.

LOCATION AND BOUNDARIES

A description of the general location of the subsection and the criteria used for locating the boundaries.

CLIMATE

A summary of climatic conditions including precipitation amount and distribution, temperature ranges, growing season, and other relevant climatic characteristics. Growing season was defined using 50 percent probability of frost cutoff dates, which results in lengths significantly longer than usually calculated for lower probabilities. Lower probabilities are more appropriate for annual field crops and garden plants than for native plants growing naturally.

TOPOGRAPHY AND GEOLOGY

A description of the shape of the land surface, changes in elevation (local relief), and major bedrock or surficial geologic parent materials. Local relief, or the amount of elevation change from a typical valley bottom to the adjacent ridge or summit, was a principle differentiating criterion. Topographic information was derived from Schroeder's "Landforms of Missouri" (an analysis based on USGS 1:24,000 quadrangles) as well as from digital and hard copy USGS quadrangles at 1:250,000 (subsections) and 1:100,000 (LTAs). Geologic information was derived primarily from statewide maps at 1:500,000 scale.

SOILS

A brief, nontechnical description of the soils and their distribution within the subsection, including parent materials and relevant depth, texture, and drainage characteristics. This information was derived from statewide general soils coverages including STATSGO and the Missouri General Soil Map, as well as county soil surveys. The descriptions were provided by NRCS staff.

HYDROLOGY

A description of the basins, streams, springs, wetlands, and other hydrologic features of the subsection, including gradients, channel morphology, water quality and quantity, channel engineering, and flooding. Information was derived from the *Missouri Water Atlas* and allied sources.

TERRESTRIAL NATURAL COMMUNITIES

Historic. A general description of the vegetation communities before Euro-American settlement. Information was derived from presettlement prairie maps, shortleaf pine historic distribution maps, and numerous written descriptions of historic Missouri.

Current. A general description of the current vegetation communities and land cover, including changes and overall conditions of existing natural communities. Information was derived from the current land cover map of Missouri (MoRAP 1999 Phase II Land Cover), the heritage database, and personal experience.

MAJOR NATURAL COMMUNITY TYPES

A list of the most common vegetation types, employing hybrid names formed by combining the vegetation-based designations of The Nature Conservancy's National Vegetation Classification with the physically based designations from the forthcoming revised *Terrestrial Natural Communities of Missouri.* A comparison of the types is provided in the Appendix. In the names, a comma between plant species denotes nearly equal importance of these species, while a hyphen indicates that the first species is usually more important; a slash (/) separates canopy from subcanopy or groundflora layers.

Note that the general terminology distinguishing forest, woodland, and savanna follows the current revision of *The Terrestrial Natural Communities of Missouri.* Forests have a closed canopy, multitiered structure, and shade-tolerant groundflora species. Woodlands have an open canopy that has 20–80 percent tree cover, an open understory, and dense, sun-loving groundflora species. Savannas are grasslands with scattered trees (less than 20 percent canopy) having common prairie groundflora species.

Rare and Restricted Natural Communities. A brief description of the small, rare, or regionally restricted natural communities associated with the subsection. Information is derived from the Missouri Natural Heritage database, natural features inventories, and personal knowledge.

NATURAL DISTURBANCES

A brief description of the natural disturbance regimes associated with the subsection. Information on fire history is based on Guyette and McGinnes's work, as well as personal observation.

RARE OR ENDANGERED SPECIES

A summary of the number and types of federal and state-listed plant and animal species, including principal habitats and regionally restricted species. Information is derived from the Missouri Natural Heritage database.

NATURAL AREAS

A summary and list of designated Missouri Natural Areas and what they represent in each subsection. Information is derived from digital coverages and attribute tables of Natural Areas.

PUBLIC LANDS

A summary of the amount and ownership of public conservation lands and Nature Conservancy preserves in the subsection. Information is derived from digital coverages of public lands in Missouri.

HUMAN GEOGRAPHY

Demographics. A summary of the Native Americans, early European and American settlers, and current population in the subsection. *American* is used in the traditional and well-understood sense of a person who lives in the United States of America or the preexisting English colonies.

Economics and Land Use. A summary of historic and current economic activities and dominant land uses.

LANDTYPE ASSOCIATIONS

An introduction to the landtype associations in the subsection, including their number and general character. Tabular descriptions of the LTAs follow the subsection description.

CONSERVATION CHALLENGES AND OPPORTUNITIES

A brief synopsis of some of the challenges and opportunities for conserving the native plant and animal communities of the subsection.

LANDTYPE ASSOCIATIONS TABLES

A table listing all LTAs in the subsection, giving an overall description of the LTA, especially its distinguishing characteristics, and describing the general location and criteria used in delineating its boundary.

Overview of Missouri

CLIMATE

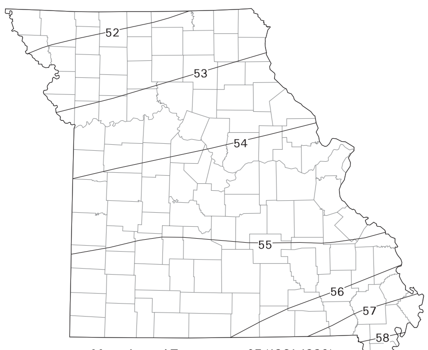
Missouri has a continental type of climate marked by strong seasonality. In winter, dry, cold air masses, unchallenged by any topographic barriers, periodically swing south from the northern plains and Canada. If they invade reasonably humid air, snowfall and rainfall result. In summer, moist, warm air masses, equally unchallenged by topographic barriers, swing north from the Gulf of Mexico and can produce copious amounts of rain, either by fronts or by convectional processes. In some summers, high pressure stagnates over Missouri, creating extended droughty periods. Spring and fall are transitional seasons when abrupt changes in temperature and precipitation may occur due to successive, fast-moving fronts separating contrasting air masses.

Missouri experiences regional differences in climates, but these differences do not have obvious geographic boundaries. Regional climates grade inconspicuously into each other. Nevertheless, several basic principles help to understand climatic differences in Missouri.

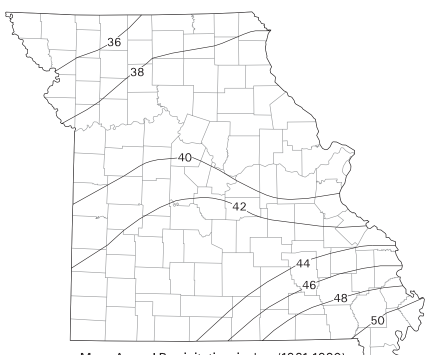
The basic gradient for most climatic characteristics is along a line diagonally crossing the state from northwest to southeast. Both mean annual temperature and precipitation exhibit gradients along this line. Mean annual temperature is lowest, 52°F, in the northwestern corner of the state and gradually increases southeastward to a high of 58° in the bootheel. Mean annual precipitation varies along the same gradient, from a low of 34 inches in the northwest to a high of 50 inches in the southeast.

Seasonal climatic variations are more complex. Mean January minimum temperature follows the same gradient, from a low of 12° in the northwest to a high of 24° in the southeast. However, mean July maximum temperature shows hardly any geographic variation in the state. Mean July maximum temperatures have a range of only three or four degrees across the state (87° to 90°), and the central Ozarks averages somewhat cooler July temperatures than other portions of southern Missouri.

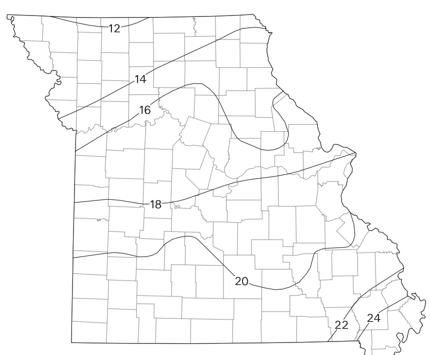
Mean January precipitation varies along the gradient from a low of 0.8 inches in the northwest to a high of 3.6 inches in the southeast. However, mean July precipitation is greatest in northeastern Missouri, largely the result of high-intensity convectional precipitation (4.4 inches), and least in southwestern Missouri (3.2 inches). Though much less precipitation falls in northern Missouri in the winter than in the summer, it tends to be seasonally effective precipitation, since temperature and evaporation rates are much lower in winter. The mean annual snowfall is 24 inches in the northwest and only 8 inches in the southeast.



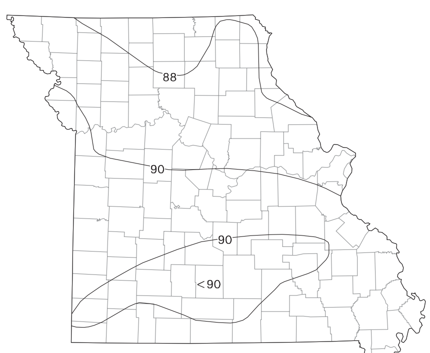
Mean Annual Temperature, °F (1961-1990)



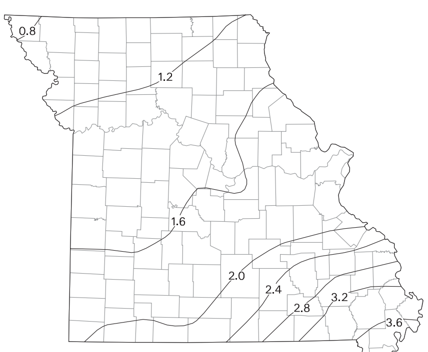
Mean Annual Precipitation, inches (1961-1990)



Mean January Minimum Temperature, °F (1961-1990)

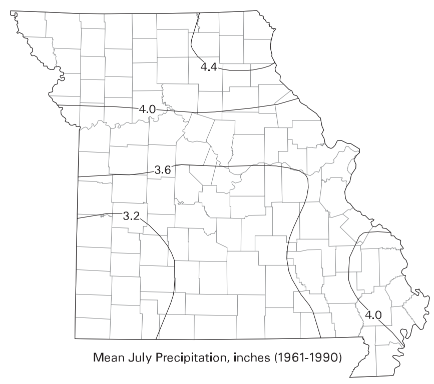


Mean July Maximum Temperature, °F (1961-1990)

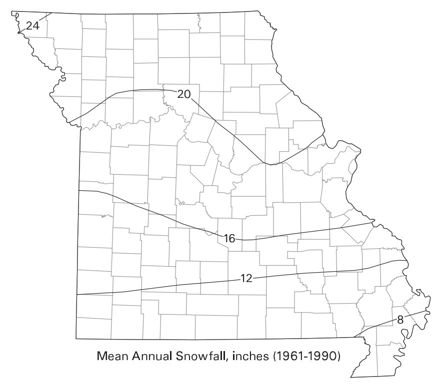


Mean January Precipitation, inches (1961-1990)

Source: Wendel, et al., 1992, Huff and Angel, 1992



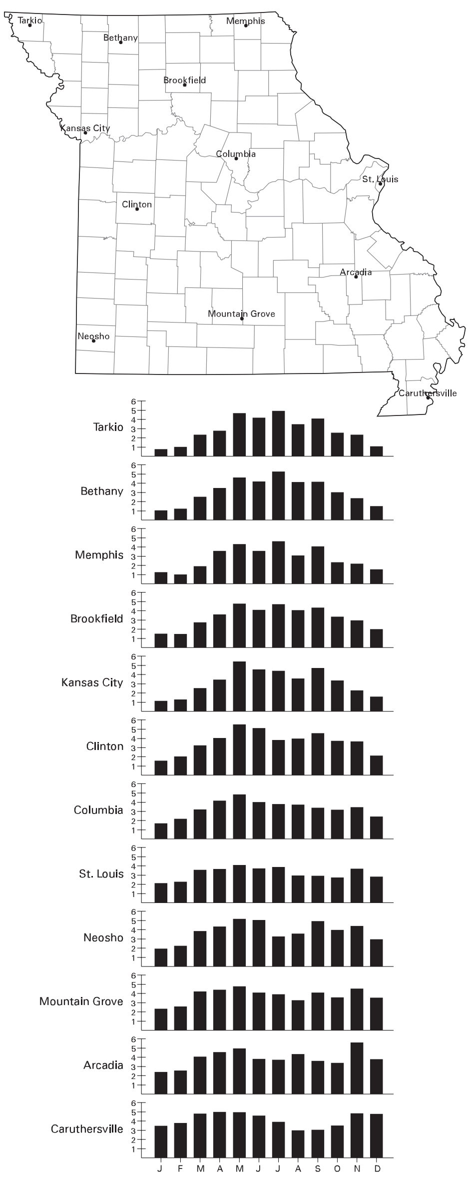
Mean July Precipitation, inches (1961-1990)



Mean Annual Snowfall, inches (1961-1990)

Mean monthly precipitation amounts are shown graphically for selected locations in Missouri on the map below. In northwestern Missouri, seasonality in precipitation is very pronounced due to strong continental influences. June precipitation, for example, averages five times greater than January precipitation. In contrast, in southeastern Missouri, seasonality in precipitation is insignificant due to the greater influence of subtropical air masses throughout the year. A conspicuous pattern to the graphs in much of Missouri is the midsummer (July–August) drop in precipitation, as shown best at Neosho and Clinton; less precipitation tends to occur in the hottest months just when demand for moisture is greatest.

All of Missouri experiences freezing temperatures every year. In northwestern



Monthly Average Precipitation (inches, 1971-2000) for Selected Stations in Missouri

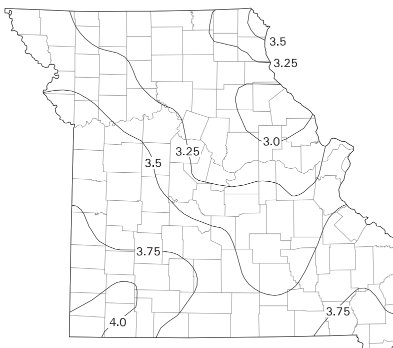
Source: Missouri Climate Center, 2001

Missouri, the average date (defined as 50 percent chance; as many freeze dates before as after the date), of the last spring moderate freeze (defined as temperatures in the range of 24–28°) is April 10. The average date of the first fall moderate freeze is October 25. In southeastern Missouri, the comparable dates are March 16 and November 20. Thus, the average length of the growing season by this liberal definition in northwestern Missouri is 198 days, and in southeastern Missouri it is 250 days. This is the definition of "growing season" used in the subsection descriptions that follow. However, the date after which there is still a 20 percent chance of moderate freeze in spring (one freeze expected during a five-year period) in northwestern Missouri is April 20, and the date before which there is a 20 percent chance of moderate freeze in fall is October 15. In extreme southeastern Missouri, the comparable dates are March 26 and November 3. Thus the length of growing season for these probabilities of freeze is much shorter and is more likely to be used for agricultural crops. The length of the growing season by this definition drops to only 178 days in northwestern Missouri and 223 days in extreme southeastern Missouri. For both probabilities (50 percent and 20 percent), for both spring and fall, the higher elevation of the Ozarks interrupts the north-south gradient across Missouri. The growing season in the Ozarks is measurably shorter than in adjacent, lower regions.

The metropolitan areas of St. Louis and Kansas City exert a significant and measurable effect on their climates. Temperatures are elevated in both regions by a few degrees, an effect known as the "urban heat island." More atmospheric particulates create a "dirtier" atmosphere of less intense light and a greater abundance of condensation nuclei. Somewhat cloudier skies and more hours of very light precipitation may result, although the total amount of precipitation may not be greater than in nonmetropolitan areas.

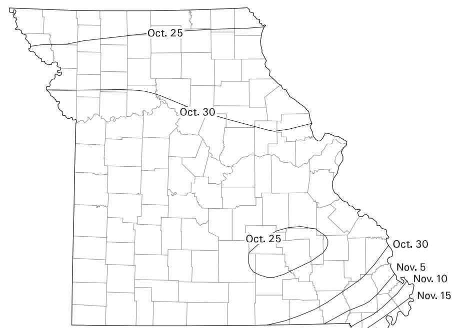
All of Missouri experiences "extreme" climate events, and such events must be considered part of the normal climate. Though infrequent in occurrence and often very geographically restricted, these "disturbances" produce environmental changes that may not otherwise have happened and that may be relatively long lasting in their effect. Among these extreme climatic events are high-intensity rains, protracted drought, heat waves and cold waves, ice storms, windstorms, and tornadoes. These climatic events, in turn, may lead to other environmental disturbances such as floods, fires, landslides, and abrupt changes in plant and animal populations and distributions.

High-intensity precipitation characterizes all regions of Missouri. The town of Holt in northwestern Missouri holds the national record for a high-intensity rain, having received 12 inches within a 42-minute period on June 22, 1947. Once every two years in southwestern Missouri one should expect one precipitation event to produce at least 4 inches of rain in a 24-hour period. Over a five-year period, one should expect one precipitation event to produce at least 5.5 inches of rain in a 24-hour period. Over a one-hundred-year period one event is expected to produce at least 9 inches of rain in a 24-hour period. Probabilities decline to the north and east away from southwestern Missouri.

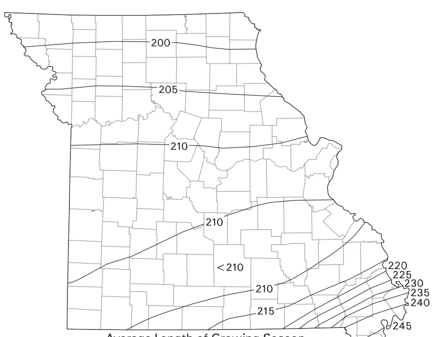


Maximum 24-Hour Rainfall, inches
2-Year Return Period (1961-1990)

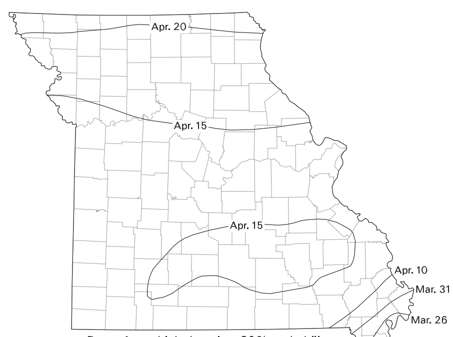
Date after which there is a 50% probability of a moderate freeze (24-28°F)



Date before which there is a 50% probability is a moderate freeze (24-28°F)

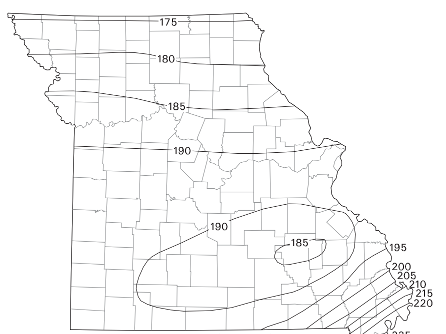


Average Length of Growing Season (using 50% probability of last spring and first fall moderate freezes)



Date after which there is a 20% probability of a moderate freeze (24-28°F)

Date before which there is a 20% probability of a moderate freeze (24-28°F)



Average Length of Growing Season (using 20% probability of last spring and first fall moderate freezes)

Drought may be conceptualized in different ways. Meteorological drought, based on precipitation records, is different from agricultural or soil-moisture drought and the physiological drought of plants. Drought is commonly thought of as a growing-season phenomenon, but precipitation deficiency during colder months does affect moisture abundance during the following warmer months. If drought is defined as a month during which less than 40 percent of normal precipitation for that month is received, then the average probability of such a dry month, based on records at Columbia, is about 15 percent, or one in seven years. For the months of April and May, the probability reduces to 8 percent, but for August and September, it rises to 18 and 21 percent, respectively, or one in five years. Thus, monthly precipitation is more variable in August and September than in April and May. The probability of three consecutive months receiving less than 60 percent of mean precipitation, again at Columbia, for the months of April through October, is 13 percent, or about one year in eight. There is no convincing evidence that severe droughts occur in Missouri with any cyclic regularity.

Drought directly affects plant and animal life by limiting water supplies, especially at times of high temperatures and high evaporation rates. Drought indirectly affects life by increasing plant and animal susceptibility to disease and the probability of fire and the severity of any fire.

As expected, minimum recorded temperatures are lowest in northern and western Missouri. The lowest temperature officially recorded in Missouri is -40° at Warsaw on February 13, 1905. Maximum recorded temperatures are also highest in northern and western Missouri. The highest temperature officially recorded in Missouri is 116° at Warsaw and Union on July 14, 1954.

Temperatures below 0° have been recorded everywhere in Missouri. Northern Missouri records an average of 3–5 days with minimum temperatures below 0°, but in some years records no temperatures below 0°. Temperatures above 100° have also been recorded everywhere in Missouri. In northern Missouri, temperatures above 90° are recorded on an average of 40–50 days each year. In southern Missouri, the average is 65–75 days, except in the higher Ozarks, where summer maximum temperatures are somewhat lower.

Tornadoes occur in all regions of the state. During the period from 1954 to 1975, Missouri experienced an average of 33 tornadoes each year. May has the greatest frequency of tornadoes, and 70 percent of Missouri's tornadoes occur during March–June.

Hail also occurs in all regions and may occur throughout the year, but it is much less likely in winter. May has the greatest number of days with hail.

Superimposed upon the basic statewide climatic patterns are local topographic influences that create topoclimatic, or microclimatic, variations. In regions of appreciable relief, for example, air drainage at nighttime may produce temperatures several degrees lower in valley bottoms than on sideslopes. At critical times during the year, this phenomenon may produce later spring or earlier fall freezes in valley bottoms. Fog, heavy dew, and higher humidities are more common in low-lying areas. Deep sinkholes often have a microclimate significantly cooler, moister, and shadier than surrounding surfaces, a phenomenon that may result in a strikingly different ecology. Microclimate is also expressed by different wind speeds due to differences in the exposure of surfaces such as bluff faces. Higher daytime temperatures of bare rock surfaces and higher albedo (reflectivity) of unvegetated surfaces may create distinctive environmental niches such as glades and balds. Slope orientation (direction) is an important topographic influence on climate. South- and west-facing slopes are regularly warmer and drier than adjacent north- and east-facing slopes. Finally, the climate within a canopied forest is measurably different from the climate of adjacent open areas where most standard weather stations are located.

The length of daylight in Missouri (including refraction of sunlight), at latitude 39° north (approximately Columbia), varies from a low of 9 hours and 26 minutes on the December solstice to a high of 14 hours and 55 minutes on the June solstice. Thus, the annual range of length of daylight between the two solstices is approximately 5 1/2 hours. Comparable figures for latitude 36°30' north (the Missouri–Arkansas state line) are 9 hours and 40 minutes and 14 hours and 30 minutes, an annual range of less than five hours. Comparable figures for latitude 40°30' north (approximately the Missouri–Iowa state line) are 9 hours and 17 minutes and 15 hours and 4 minutes, or an annual range of just less than 6 hours.

TOPOGRAPHY

The highest peak in elevation is the 1,772-foot summit of Taum Sauk Mountain in Iron County, although the highest continuous upland surface area, above 1,600 feet, lies in Webster County, over one hundred miles west of Taum Sauk.

The elongated Ozark crest, called the Ozark Divide, between the St. Francois knobs and southwestern Missouri, lies generally between 1,300 and 1,600 feet. The southward slope from the crest is steeper than the northward slope toward the Missouri River, causing the south-slope rivers to have steeper gradients than the north-slope rivers.

A broad topographical lowland lies at general elevations between 650 and 900 feet on the northwest flank of the Ozarks. It extends from southeastern Kansas to the lower Grand River in Chariton County. From this lowland, land elevation rises to more than 1,000 feet in Jackson County.

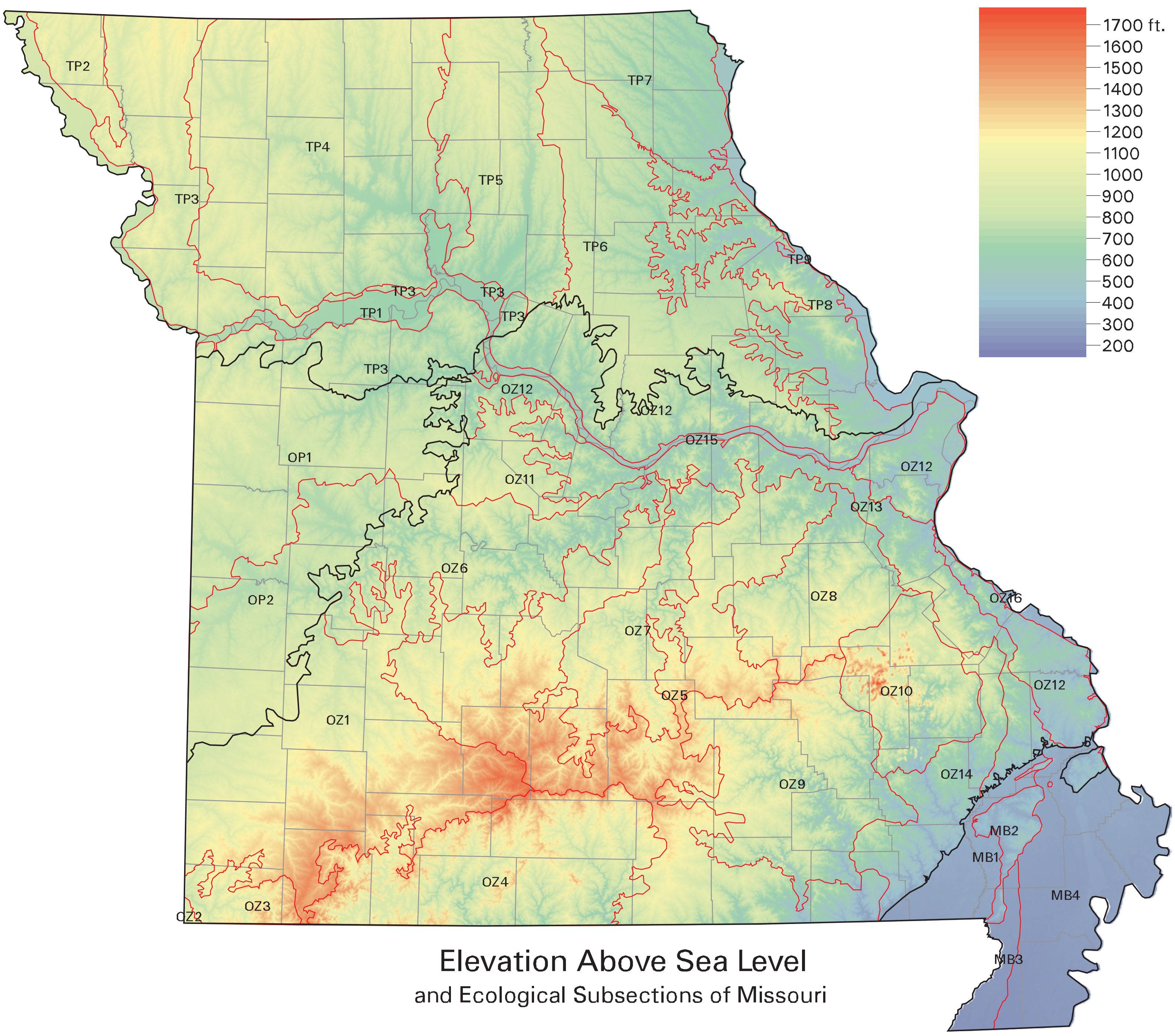
North of the Missouri River, the land continues to rise gradually northward, reaching elevations of 1,200 feet in northwestern Missouri, which are elevations comparable to the average elevation of the Ozarks. In northeastern Missouri, the Grand Divide, a flat-surface interfluve with elevations of 900–1,000 feet, reaching from Warren County to the Iowa line, separates the Missouri and Mississippi River drainages.

The southeastern lowlands lie between 240 and 335 feet in elevation, not including the isolated ridges that rise above the alluvial plain. This low-relief plain slopes southward from Cape Girardeau to the Arkansas state line at an average gradient of one foot per mile, and that southward slope accounts for much of the range of elevations of the alluvial plain. The lowest land elevation in Missouri is approximately 230 feet, where the Little River drainage ditches and the St. Francis River leave the state in Dunklin County.

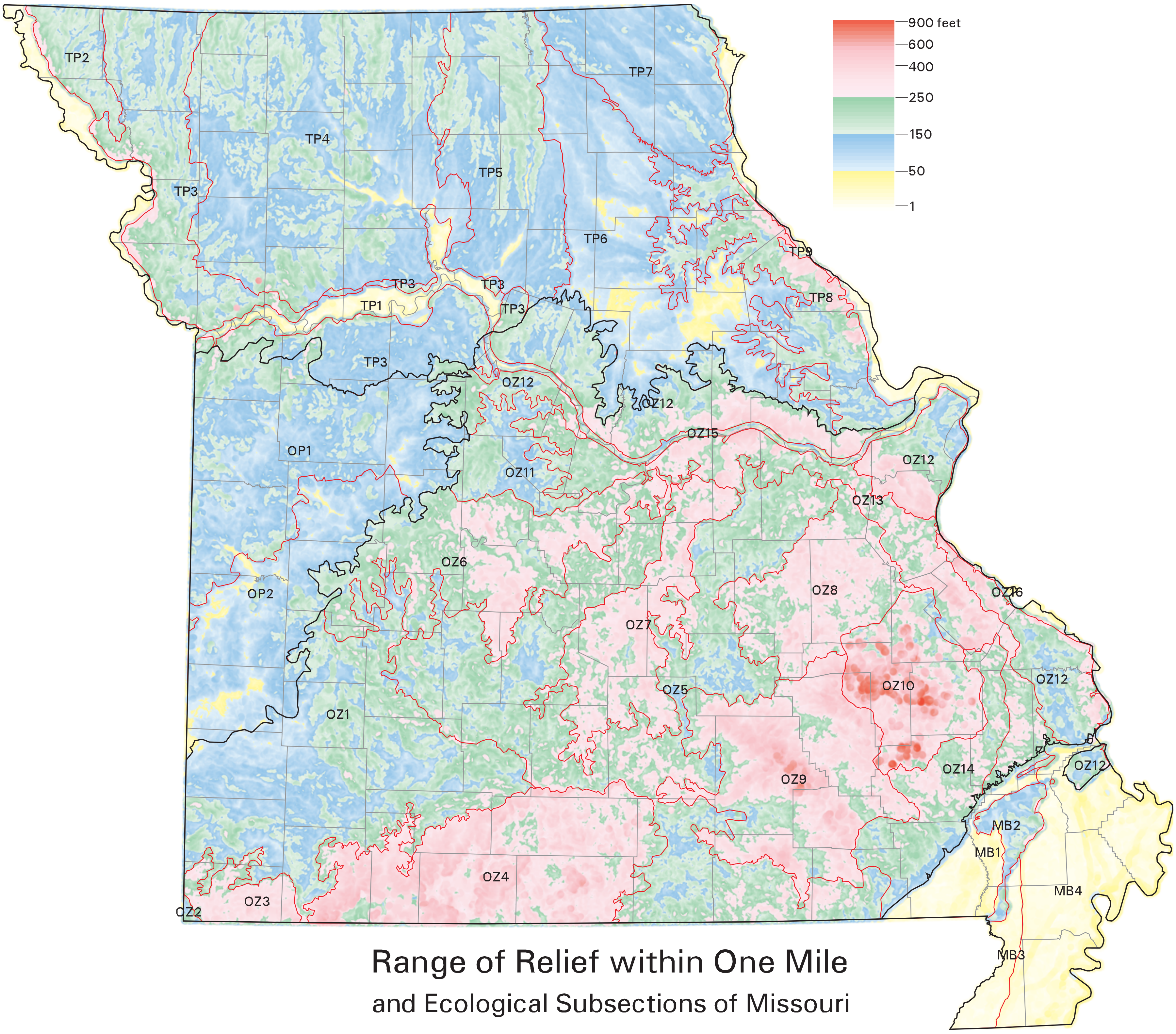
The prevailing land slope over most of Missouri, both in the Ozarks and in the upland plains, lies within the range of 3–10 percent. Gentle slopes, those less than 3 percent, characterize upland interfluves throughout the state. Gentle slopes are more extensive in southwestern, west-central, and northeastern Missouri where, in some places, the upland surface becomes essentially flat. Near-flatness also characterizes the alluvial surface of the southeastern lowlands. Steep slopes, those over 20 percent, are most common in the eastern Ozarks, the White River country, and locally elsewhere, especially in breaks and blufflands along the major rivers.

Relief is defined for this ecoregion atlas as "local relief," the difference between high and low elevations within a one- or two-mile distance or between a perennial stream valley and an adjacent major ridge. A visual depiction of local relief within one mile is provided on pg. 12.

It is immediately apparent that, except for the southeastern alluvial plain, the



Elevation Above Sea Level
and Ecological Subsections of Missouri



Range of Relief within One Mile
and Ecological Subsections of Missouri

surface is fluvially dissected to greater or lesser degrees, even the glaciated plains of northern Missouri. The pattern of stream dissection and local relief in Missouri consists of three major regions: Ozark highlands, plains, and southeastern lowlands.

The Ozarks are the most thoroughly dissected ecoregion in Missouri. Highest local relief is in the St. Francois knobs and basins, along the Current and Eleven Point Rivers, in the White River region, and along the Burlington Escarpment in the eastern Ozarks, where local relief is 400–600 feet. The highest relief measured in Missouri, within a one-mile distance, is 946 feet, in Madison County, between the St. Francis River and the summit of Black Mountain. Relief is generally 250–400 feet in most of the other river hills of the Ozarks. Relief is less in the western Ozarks and in the less-dissected interfluves of the Ozarks, where it averages 100–200 feet.

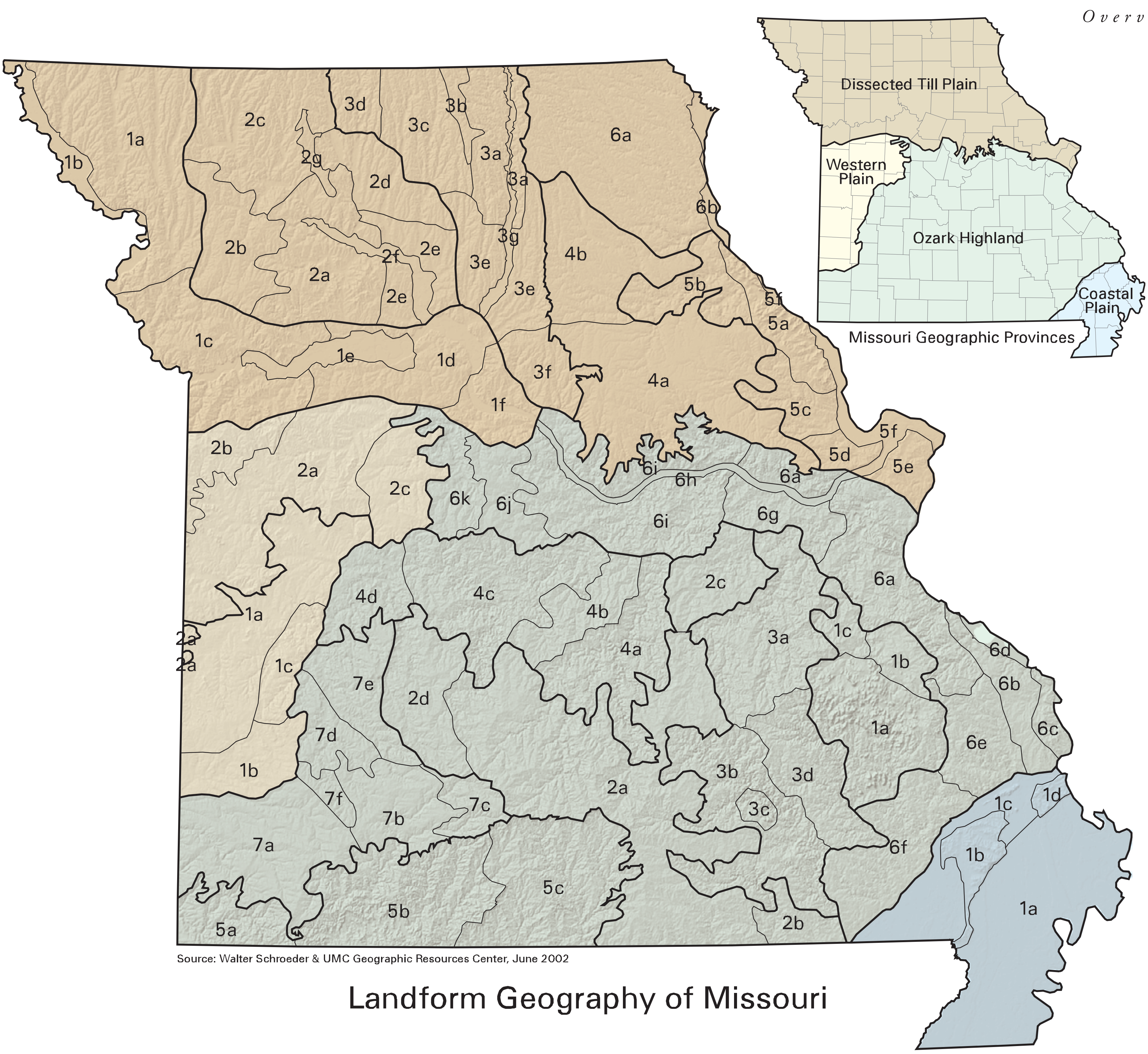
Throughout the plains of western and northern Missouri, stream dissection is less and relief averages 50–200 feet, generally about half that of most of the Ozarks, but it approaches Ozark numbers in the blufflands along the Missouri and Mississippi Rivers. Because of the prevalence of moderately steep slopes and moderately high relief in these areas, many of the ecoregion units in the plains are called "hills," while from a broader midwestern perspective, northern and western Missouri is regarded as "plains."

Relief is lowest in the broad alluvial plains of southeastern Missouri, where hardly any stream dissection has occurred and elevations commonly do not differ more than 20 feet over dozens of square miles. A significant fraction of this is accounted for by the southward slope of the plain. This landscape of very low relief is interrupted prominently by Crowley's Ridge, with relief up to 150 feet.

A map of landform regions of Missouri, based on relief, lithology, geomorphic process, and geographic pattern is shown on page 13. As would be expected, the divisions on the map are strikingly similar to the ecoregion subsections of Missouri, because landforms and geomorphology are basic factors in the creation of ecoregions at the subsection level. This map serves as an important starting point for ecoregion mapping. Differences are related to the added importance of soils and vegetation in ecoregion mapping.

GEOLOGY

The basic state geology map shows the geographic occurrence of formations by age. Most of the formations are Paleozoic in age. Ages are generally related to lithology (type of rock), but rocks of essentially the same lithology, like sandstone, can be present in formations of different ages. Lithology, much more than age of forma-



Landform Geography of Missouri

Coastal Plain Province

1. Southeastern Lowland Section
   - 1a. Eastern Lowland
   - 1b. Crowley's Ridge
   - 1c. Western Lowland
   - 1d. Benton Hills

Dissected Till Plain Province

1. Loess Hills Section
   - 1a. Nodaway Deep Loess Hills
   - 1b. NW Missouri Alluvial Plain
   - 1c. Missouri River Scarplands
   - 1d. Marshall Plain
   - 1e. Wakenda Alluvial Plain
   - 1f. Boonslick Hills

2. Grand River Dissected Plain Section
   - 2a. Glaciated Scarplands
   - 2b. Cameron Upland
   - 2c. Upper Grand River Hills
   - 2d. Trenton Hills
   - 2e. Meadville Plain
   - 2f. Grand River Alluvial Plain
   - 2g. Gilman City Upland

3. Chariton Hills Section
   - 3a. Upper Chariton Hills
   - 3b. Unionville-Green City Upland
   - 3c. Locust-Medicine Creek Hills
   - 3d. Weldon Hills
   - 3e. Middle Chariton Rolling Hills
   - 3f. Harrisburg Hills
   - 3g. Chariton Alluvial Plain

4. Glacial Plains Section
   - 4a. Audrain Plain
   - 4b. Shelby Plain

5. Mississippi River Hills Section
   - 5a. Lincoln Hills
   - 5b. Salt River Hills
   - 5c. Cuivre River Hills
   - 5d. St.Charles Low Hills
   - 5e. St. Louis Plain
   - 5f. Mississippi & Missouri Alluvial Plains

6. Wyaconda Dissected Plain Section
   - 6a. Wyaconda Ridges & Valleys
   - 6b. Upper Mississippi Alluvial Plain

Ozark Highland Province

1. St. Francois Knobs and Basins Section
   - 1a. St. Francois Mountains
   - 1b. Farmington Plain
   - 1c. Potosi Plain

2. Central Plateau Section
   - 2a. Central Plain
   - 2b. Ripley Dissected Plain
   - 2c. Bourbeuse Plain
   - 2d. Bolivar-Buffalo Plains

3. Courtois Hills Section
   - 3a. Meramec River Hills
   - 3b. Current River Hills
   - 3c. Eminence Knobs
   - 3d. Black River Hills

4. Osage-Gasconade Hills Section
   - 4a. Gasconade Hills
   - 4b. Iberia Upland
   - 4c. Lake Of The Ozark Hills
   - 4d. Truman Lake Hills

5. White River Hills Section
   - 5a. Elk River Hills
   - 5b. Branson Hills
   - 5c. North Fork Hills

6. Ozark Border Section
   - 6a. Eastern Ozark Cuestas
   - 6b. Perryville Karst Plain
   - 6c. Cape Hills
   - 6d. Bois Brule Bottom
   - 6e. Bollinger Hills
   - 6f. SE Ozark Hills & Flatwoods
   - 6g. Franklin Low Hills
   - 6h. Lower Missouri River Alluvial Plain
   - 6i. Central Missouri Hills
   - 6j. Tipton Upland
   - 6k. Lamine River Hills

7. Springfield Plain Section
   - 7a. Spring River Tableland
   - 7b. Springfield Karst Plain
   - 7c. Seymour Highland
   - 7d. Sac River Hills
   - 7e. Escarpment Hills
   - 7f. Chesapeake Fault-Line Hills

Western Plains Province

1. Cherokee Plains Section
   - 1a. Nevada Lowland
   - 1b. Golden City Plain
   - 1c. Clear Creek Plain

2. Osage Plains Section
   - 2a. Warrensburg Plain
   - 2b. Belton Upland
   - 2c. Pettis Plain

Source: Walter Schroeder & UMC Geographic Resources Center, June 2002 tion, is a primary factor in the configuration of the land surface, the formation of surficial material and soils, and presence of special features like karst.

The state geology map may be reduced to three primary patterns. In the Ozarks, the pattern is one of roughly concentric elliptical rings around a center in the St. Francois Mountains of the eastern Ozarks. The ellipses are elongated farthest from the center in a southwest direction towards Oklahoma. The geologic structure of the Ozarks is that of a broad dome with its center in the St. Francois Mountains, where the oldest rocks of Missouri are exposed at the surface. These are Precambrian igneous rocks of more than one billion years in age. They are followed successively by elliptical rings of Cambrian sandstones and dolomites and Ordovician dolomites, sandstones, and limestones. The most widespread formations are the Cambrian Eminence and Potosi dolomite (Cep), Ordovician Gasconade dolomite (Og), Ordovician Roubidoux sandstone and dolomite (Or), Ordovician Jefferson City–Cotter dolomite (Ojc), and Ordovician St. Peter sandstone (Osp). Beyond them, Silurian and Devonian formations of various lithologies are scattered in a narrow, discontinuous arc on the east and north. Still farther out from the structural center, Mississippian formations, chiefly limestones, almost completely encircle the dome. The most widespread of these are the Mississippian Osagean and Meremecian series limestones (Mo, Mm).

Dolomites and limestones, together called "carbonate rocks," greatly dominate the Ozarks. The prevalence of carbonate rocks causes all of the hill regions except the St. Francois Mountains to have broadly similar landform characteristics; the Ozark surface is one of repetitious broad uplands and ridges interspersed by valleys of varying depth and width. The carbonate rocks are soluble, and thus most of the surface is karstic to some degree. Many of the carbonate formations are strongly cherty. The smaller areas of igneous and sandstone formations interrupt the widespread carbonate surface with their own distinctive landscapes.

Because the stratigraphic dip away from the structural center is steeper eastward into Illinois than westward, the widths of the elliptical rings are much narrower on the east than on the west. In fact, the stratigraphic dip is hardly present westward from the center to Springfield, so that the Ozarks comes closest to being a true plateau along this broad crest, or axis, of the Ozarks. In general, this structural high is also a topographic high, and it serves as the regional drainage divide between north- and south-flowing rivers. The concentric ring pattern is abruptly truncated in the southeast by the straight Ozark Escarpment, which separates the Ozarks from the southeastern lowlands.

The second broad geologic pattern in the state trends northeast to southwest, lying to the north and west of the Ozark rings. This region in western and northern Missouri is composed mostly of Pennsylvanian-age formations. The most widespread are the Cherokee-Krebs limestone and shale (Pck), Marmaton limestone and shale (Pm), and the Kansas City Group limestone and shale (Pkc). These are "cyclic" formations and consist of alternating thin beds of shales (and coals), limestones, and sandstones, of which the shales account for the greatest surface area. The limestones and sandstones are more resistant to erosion, and where they occur they often create northeast–southwest belts of somewhat rougher terrain, called escarpments. All of the Pennsylvanian formations dip gently northwestward away from the Ozarks. Throughout most of northern Missouri, the Pennsylvanian formations are buried under glacial till. In northeastern Missouri (Marion, Ralls, Pike, and Lincoln Counties) a smaller, but pronounced, structure, the Lincoln Anticline or Fold, brings older Ordovician and Mississippian formations (mostly carbonate rocks) to the surface. The Lincoln Anticline region may be considered an outlier of Ozark geology and terrain on the north side of the Missouri River.

The third broad geologic pattern occupies Missouri southeast of the Ozark Escarpment. Here, bedrock is not important for landforms (except for Crowley's Ridge), and surface features are primarily the result of Tertiary, Pleistocene, and Holocene marine and alluvial deposition. This region of Missouri contains most of the epicenters of earthquakes associated with the New Madrid fault system. Numerous seismic events are recorded in the region each year, but the vast majority of them are not felt by humans.

HYDROGRAPHY

Streams in Missouri occur in a wide variety of sizes and patterns, from which inferences and associations may be made with geology, topography, and geomorphic process. *(See map on pg. 16.)*

The southeastern lowland (exclusive of the Mississippi River) is now a region of few natural alluvial rivers but hundreds of human-made drainage ditches and channels, many of them arrow-straight. The region's natural hydrography of perennial and seasonal wetlands has been more modified by human action than the hydrography of any other region of Missouri. The region lost a major input of runoff from the Ozarks when the Headwaters Diversion Channel was excavated across southern Bollinger and Cape Girardeau Counties, diverting several streams directly to the Mississippi at Cape Girardeau.

In the Ozarks, streams may be conveniently divided between south-slope and north-slope drainage systems. The White, Norfork, Eleven Point, Current, Black, and St. Francis are the chief south-slope systems, and the Osage (including the Sac, Pomme de Terre, and Niangua), Gasconade, and Meramec are the chief north-slope systems. All of the major Ozark streams are considered to be entrenched into the region's bedrock and have meandering valley patterns. Because of this deep entrenchment into water-bearing strata, all Ozark streams are influenced to some degree by groundwater flow from large springs. Base flow, as opposed to surface-water runoff, comprises a significant proportion of stream discharge. Ozark stream systems are dendritic in pattern, although some (especially the Osage, Gasconade, Meramec, and Black) have strongly asymmetrical patterns with more, larger, and longer tributaries on one side of the trunk stream. In general, Ozark stream channels have been less affected by channel engineering activities, such as straightening and bank stabilization, than streams elsewhere in the state.

In northern Missouri, subparallel patterns of drainage prevail. In the northeast, as far west as Putnam County, subparallel streams flow southeasterly. In the north-center and northwest, streams (except the trunk of the Grand River) flow almost due south. The channels of the streams in northern Missouri are naturally intensely meandering on broad, wet alluvial plains, but many of them have been straightened by channelization.

In west-central Missouri, stream patterns are dendritic. Channels, formerly low-gradient and intensely meandering on very broad alluvial plains, have been straightened by channelization.

The Spring, Elk, and upper James Rivers in southwestern Missouri are the only sizable streams in Missouri that flow westward. The first two are part of the Neosho (Grand) River system, which is part of the Arkansas River system.

The channels of both the Mississippi and Missouri Rivers have been significantly modified by channel engineering, largely for navigation, flood-control, and bank-stabilization purposes. The Mississippi River above St. Louis has been modified by a series of low dams with locks for barge navigation. Below St. Louis, channel engineering basically takes the form of bank stabilization. The Missouri River throughout the state has been narrowed by engineering works to approximately one half of its former width and deepened as a result. Most islands have been eliminated, meanders rounded for navigation, and banks stabilized by rock revetments and rock dikes.

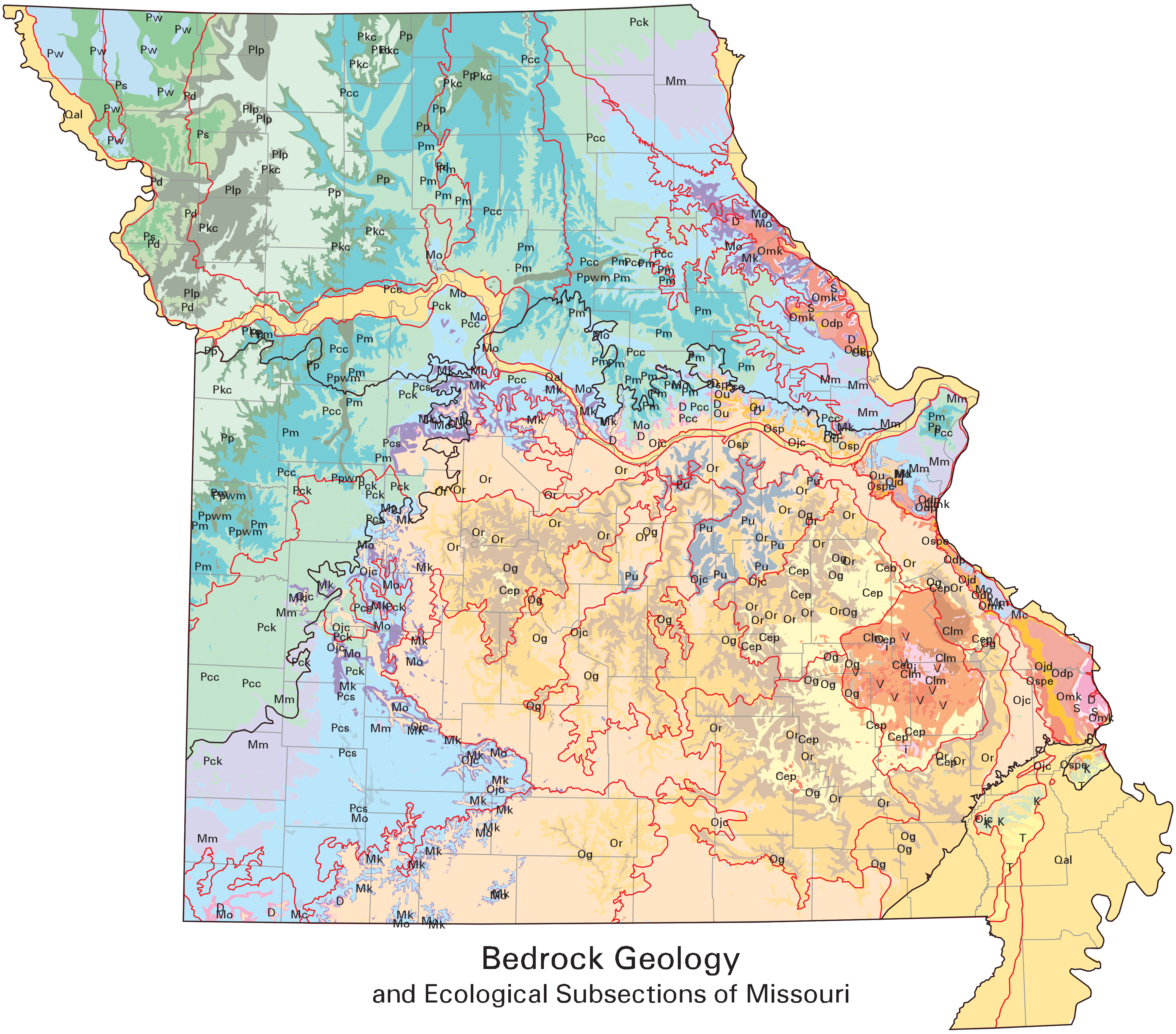
Areas that are conspicuous on state maps for their lack or sparsity of streams are of three types. Some are well-developed karst plains (Perry, Greene, Christian, and St. Louis Counties), some are urbanized areas (Jackson and Greene Counties; St. Louis city), and some are permeable alluvial surfaces (Holt, St. Charles, New Madrid, and other counties in the southeastern lowlands).

"Losing streams," or "sinking streams" are streams in which a portion of the discharge is known to be lost through the streambed to underground flow. Probably many losing streams have yet to be identified. Those identified so far are located in the carbonate, karst regions of the Ozarks and are prominent in the James and Finley basins south of Springfield, in the drainage basins around West Plains, and in the Niangua, Auglaize, Roubidoux, upper Meramec, upper Current, and upper Black River basins. The water lost from these streams often feeds large springs and it may reemerge in streams of other drainage basins. *(See map on pg. 16.)*

The only natural lakes in Missouri are oxbows (former river channels) in river alluvial plains, sinkhole ponds in karst regions, and, by far the most numerous, lakes in the wetlands of southeastern Missouri. Some of these wetlands were true perennial lakes of open water, but most were swamps of seasonal wetness. Virtually all of the extensive wetlands of southeastern Missouri have been drained. Other alluvial wetlands occur along the Grand and other rivers in northern Missouri and along the upper Osage and other rivers in west-central Missouri. Many of these have also been drained.

Human-made lakes and ponds are ubiquitous across the state and represent one of the most conspicuous changes in the hydrographic landscape. Because of them, surface water is much more locally accessible to animals and fish than in earlier times, before the twentieth century. Estimates of the number of ponds and small lakes in Missouri range as high as 300,000, or an average of almost five per square mile throughout the state. However, they are much more numerous per square mile in the northern and western plains regions than in the Ozarks. Many are small ponds (less than one-half acre) for stock watering. Lakes also occupy strip pits of former coal mines. Other lakes have been constructed for residential developments and water supplies. The largest lakes, those created by dams of the U.S. Army Corps of Engineers and electric power companies, are most numerous in the western Ozarks. The largest impoundments in Missouri by surface area are the Lake of the Ozarks (60,000 acres at normal or conservation pool) and Harry S. Truman Reservoir (55,600 acres, which expands to 209,300 acres or 327 square miles at maximum flood-control pool elevation). The Gasconade, Meramec, and Current Rivers of the eastern Ozarks have no large dams or lakes on them and therefore are Missouri's largest "free-flowing" rivers.

The surface of Missouri was essentially created by fluvial, or stream, processes operating on different types of earth materials. The numerous drainage basins organize the land surface into units of energy flow and geomorphic development and form natural geographic units for land, water, and biological management purposes. They exist in hierarchical systems, from the small basins of fingertip or "first-order" streams, to the huge basins of the Osage, Missouri, and Mississippi Rivers. All of Missouri lies within the Mississippi River basin, and about half of the state within the Missouri River basin. Basin shapes range from the compact Lamine and Cuivre basins to the elongated Platte, Pomme de Terre, and North Fabius basins. Basin shapes affect the nature of flooding. It should be noted that subterra-



Bedrock Geology
and Ecological Subsections of Missouri

Cenozoic

Quaternary
- Qal - Alluvium

Tertiary
- T - Sandstone & Shale

Mesozoic

Cretaceous
- K - Siltstone & Sandstone

Paleozoic

Permian
- Pic - Indian Cave Sandstone

Pennsylvanian
- Pw - Wabaunsee Group Limestone & Shale
- Ps - Shawnee Group Limestone & Shale
- Pd - Douglas Group Limestone & Shale
- Plp - Lansing-Pedee Limestone & Shale
- Pkc - Kansas City Group Limestone & Shale
- Ppwm - Warrensburg Channel Sandstone
- Pp - Pleasanton Sandstone & Shale
- Pm - Marmaton Limestone & Shale
- Pcc - Cherokee-Cabaniss Limestones
- Pcs - Channel Sandstone
- Pu - Pennsylvanian Undifferentiated
- Pck - Cherokee-Krebs Limestone & Shale (Coal)
- Ph - Hale Sandstone

Mississippian
- Mc - Chesterian Series Limestone & Sandstone
- Mm - Meramecian Series Limestone
- Mo - Osagean Series Limestone
- Mk - Kinderhookian Series Limestone & Shale

Devonian
- D - Devonian Formations
- Dd - Diatremes

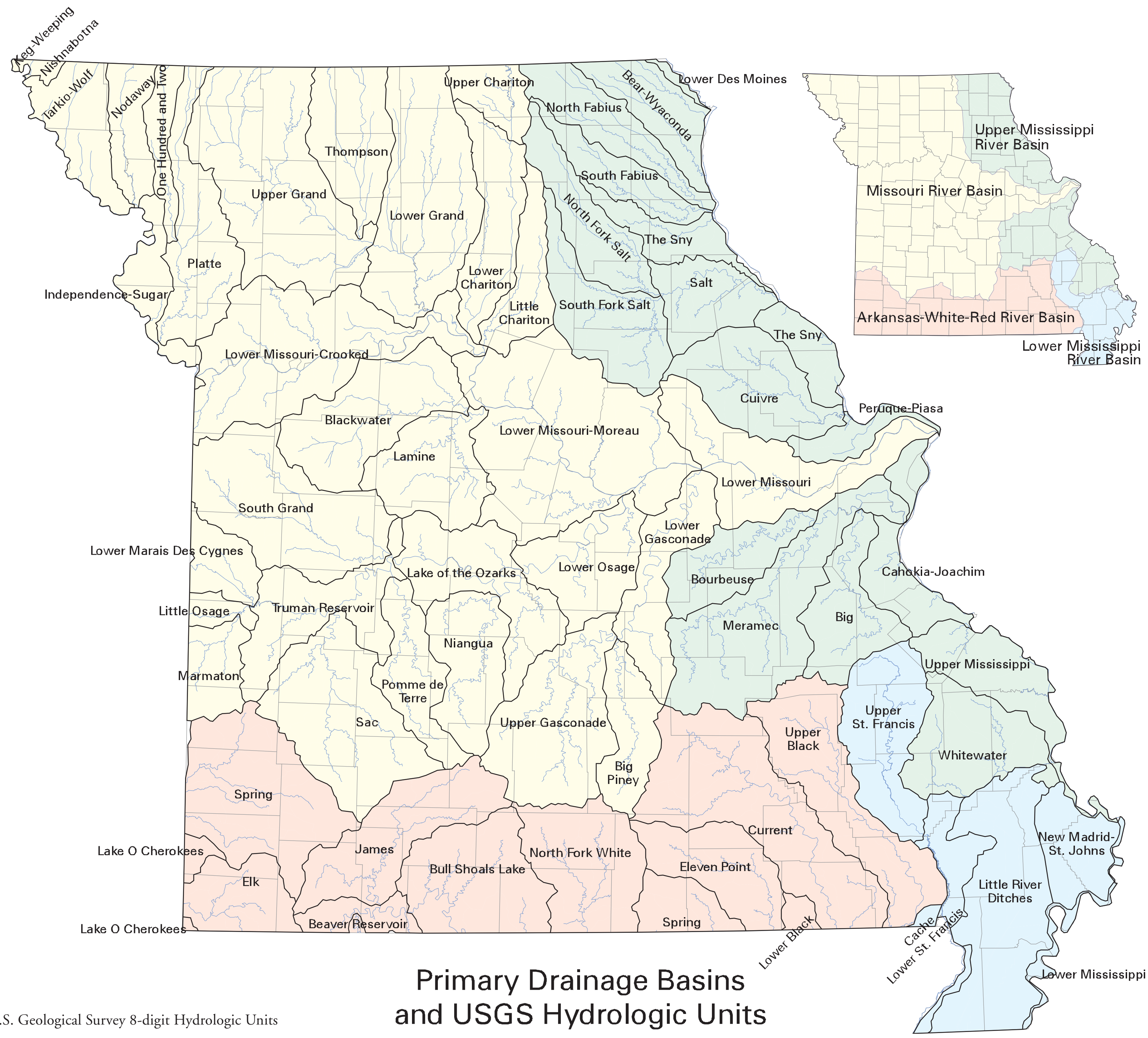
Silurian
- S - Undifferentiated Limestone

Ordovician
- Ou - Undifferentiated Dolomite
- Omk - Maquoketa-Kimmswick Shale & Limestone
- Odp - Decorah-Plattin Limestone & Shale
- Ojd - Joachim-Dutchtown Dolomite & Limestone
- Ospe - St. Peter-Everton Sandstone & Sandy Dolomite
- Osp - St. Peter Sandstone
- Ojc - Jefferson City-Cotter Dolomite
- Or - Roubidoux Sandstone & Dolomite
- Og - Gasconade Dolomite

Cambrian
- Cep - Eminence-Potosi Dolomite
- Ceb - Elvins Group & Bonne Terre Dolomite & Shale
- Clm - Lamotte Sandstone

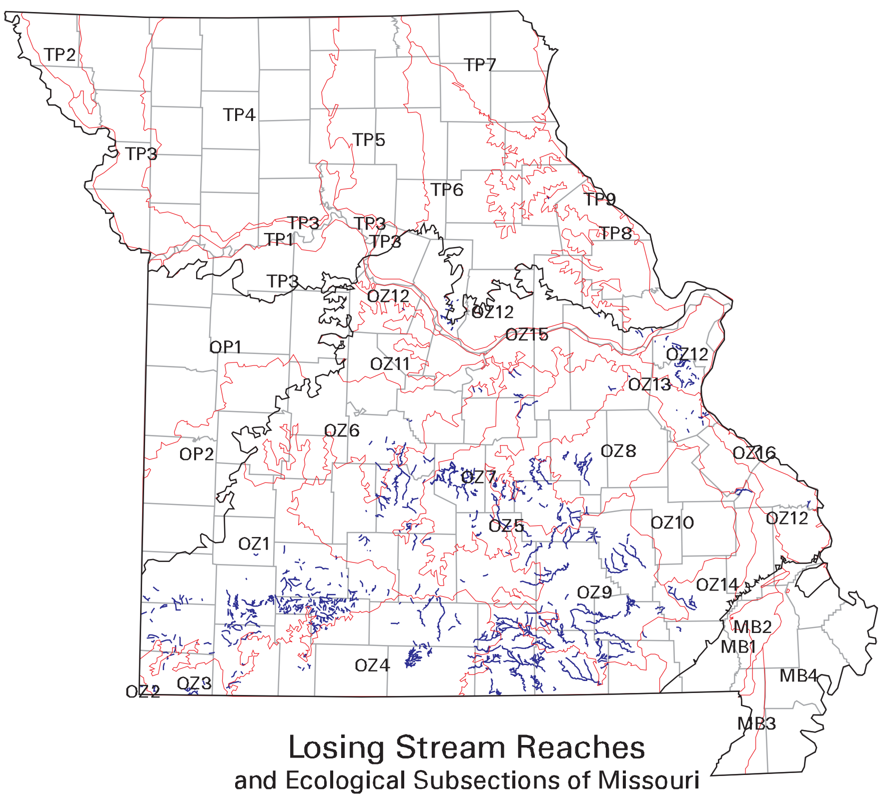
Precambrian
- d - Igneous Diabase
- i - St. Francois Mts. Intrusive Suite
- V - St. Francois Mts. Volcanic Supergroup

Source: Missouri Geological Survey–Missouri Department of Natural Resources



Primary Drainage Basins and USGS Hydrologic Units

Source: U.S. Geological Survey 8-digit Hydrologic Units



Losing Stream Reaches and Ecological Subsections of Missouri

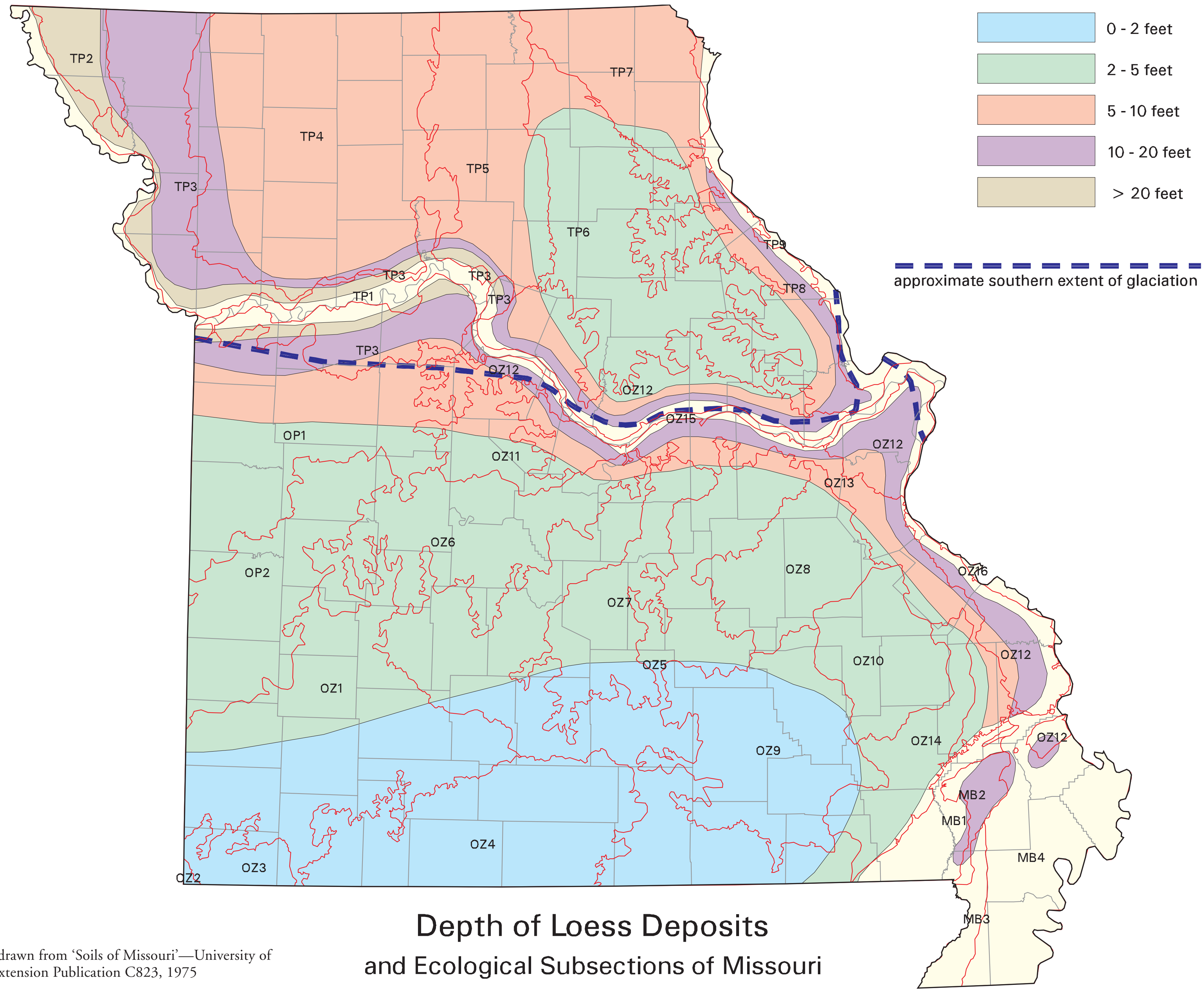
Source: UMC Geographic Resources Center (1995)

nean drainage in cavern systems may have substantially different geographic patterns and hydrographic basins than those shown for surface drainage. That is, a large spring may contribute water to a stream from a different geographic area than the mapped drainage basin for the stream. No state map yet exists that shows subterranean drainage basins.

PLEISTOCENE-HOLOCENE FEATURES

Several glaciers invaded Missouri during the Pleistocene Epoch, roughly the last two million years of earth history, but the great length of time since their recession has allowed postglacial erosional and depositional processes to rework the surface considerably and destroy much of the glacial landscape. "Fresh" glacial features are not present in Missouri; the land surface in glaciated regions is essentially a fluvial product constructed on a surface of glacial materials. The southern limit of Pre-Illinoisan glaciation (formerly separated into Kansan and Nebraskan stages) lies south of the Missouri River west of Jefferson City and north of the river east of that city *(see pg. 17)*. This boundary is a very generalized, inferred line and cannot be used for local purposes of high geographic resolution. For example, parts of Lincoln and Pike Counties north of the line show no evidence of ever having been glaciated, and, conversely, glacial erratics have been found south of the boundary south of the Missouri River in Jefferson City. A glacier of the later Illinoisan stage extended across the Mississippi River into Missouri at St. Louis. The most recent major stage of Pleistocene glaciation, the Wisconsinan, did not reach Missouri, although it was experienced through climatic, hydrologic, and biological changes.

The Missouri and Mississippi Rivers, and probably also the Des Moines, are the only true glacial meltwater streams of the state, and their alluvial plains are under-



Source: Redrawn from 'Soils of Missouri'—University of Missouri Extension Publication C823, 1975

Depth of Loess Deposits
and Ecological Subsections of Missouri

lain by as much as one hundred feet of glaciofluvial sediment. Other Missouri streams did not drain away from active Illinoisan or Wisconsinan glaciers, although their discharges fluctuated according to wetter and drier climatic episodes of the Pleistocene and Holocene. In addition to the Mississippi, the Ohio River in late glacial time deposited enormous amounts of glaciofluvial sediments in southeastern Missouri.

The thickness of Pleistocene glacial deposits (till) in northern Missouri varies greatly and often within short distances. In places where glacial deposits filled preexisting valleys, they may be over three hundred feet thick, but in most places till is less than one hundred feet. In many places, especially closer to the southern limit of glaciation, till has been completely removed by postglacial erosion, and the underlying Paleozoic bedrock appears at the surface.

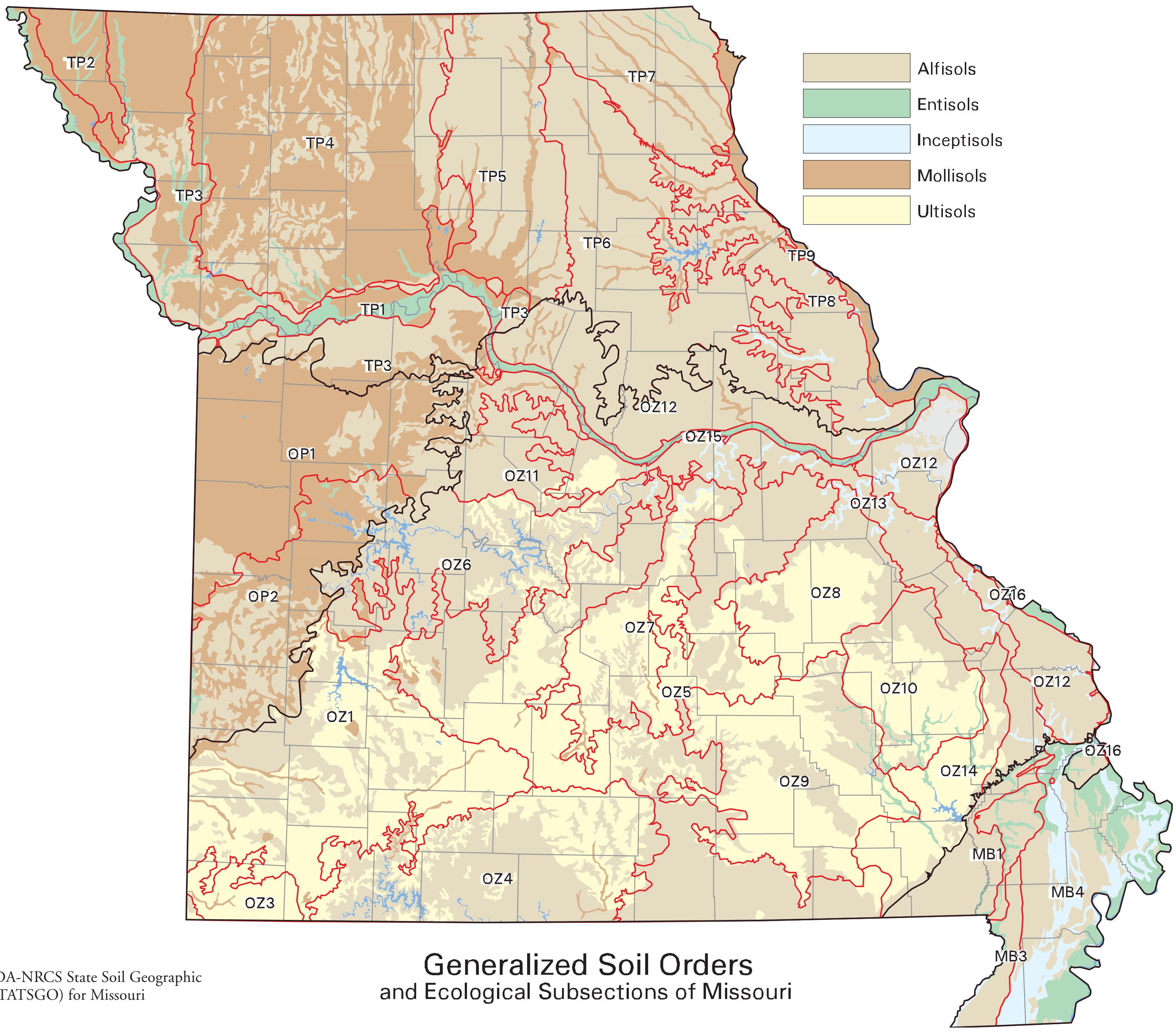
Loess (wind-deposited silt) is an important Pleistocene-Holocene feature associated with glaciation. As seen on the map, the generalized distribution and depth of loess lacks good spatial correlation with the ecoregional lines overlaid on it. Loess presumably mantled most of the state, but where it was formerly less than two feet thick, it has probably been either removed by soil erosion and redeposited in valleys or plowed into the residuum or glacial till beneath it. Even in northern Missouri, hillslopes may have had most of their loess mantle removed, although it continues to cap the ridges and uplands. Geographic variations in the thickness of loess reflect the function of the Missouri and Mississippi Rivers as Pleistocene meltwater streams. Loess has been measured to depths greater than one hundred feet in blufflands in northwestern Missouri, but these measurements may be from silted-in ravines or in deposits plastering exposed bluff faces and therefore exaggerate the general thickness of loess. Loess is thickest along the two major meltwater-river valleys and thins rapidly away from them. Loess is thicker, as a rule, in west- and south-facing blufflands of those two rivers, but in any one locality it is thicker on river-facing slopes than on slopes facing away from the river valley. Loess is thinnest in interior northern Missouri in locations farthest removed from the Missouri and Mississippi Rivers. It is also thin throughout the Ozarks. Crowley's Ridge has significant depths of loess on it.

SURFICIAL MATERIALS

Residuum derived from the physical disintegration and chemical decomposition (solution) of bedrock forms most of the land surface south of the Missouri River. In the Ozarks, residuum is usually from ten to forty feet thick, but it ranges up to two hundred feet thick and to even greater thicknesses locally. In most of the Ozarks, this material is primarily a cherty clay, cherty sandy clay, or cherty silty clay. The carbonate fraction of bedrock decomposes chiefly to clay, while the insoluble chert remains as rock fragments. The size of chert fragments and their percentage of the residual mass vary greatly. Percentages of rock fragments are lower on the smooth upland surfaces and higher on the hillsides of dissected areas. Because so much of the carbonate portion of the rock mass has been dissolved and removed, the insoluble lag chert usually forms a higher percentage of the residuum than it does in the parent bedrock.

Chert-free clays form the innermost lithologic belt around the St. Francois knobs. Small areas of sandy residuum lie just northeast of the St. Francois knobs in a very narrow arc from Cape Girardeau to Montgomery County and scattered elsewhere in the Ozarks wherever the parent material is sandstone. Often the toponym Sand Creek or Sandy Creek indicates local sandy residuum.

In the plains of west-central Missouri, the residuum is basically a clay, becoming



Source: USDA-NRCS State Soil Geographic Database (STATSGO) for Missouri

Generalized Soil Orders
and Ecological Subsections of Missouri

sandier closer to the Ozarks and siltier in the Kansas City region. Despite the low relief of the western plains, residuum is thinner (generally less than fifteen feet) than in any other major state region, and bedrock exposures are common.

The glacial till of northern Missouri is a silty clay or clay, but with locally coarser materials, especially where glacial deposits fill preglacial valleys. Glacial deposits in extreme northeastern Missouri are noticeably sandier. Paleosols (buried soils) and accretion gley, both formed by pedologic processes since the retreat of the glaciers, are major components of weathered till. Weathered till is several feet thick on smooth uplands but less thick on hillslopes. Where till is absent in northern Missouri, the surficial material is residuum formed from the weathering of Paleozoic sedimentaries. In the blufflands on both sides of the Missouri and Mississippi Rivers, loess is sufficiently thick to be considered the surficial material.

Alluvium forms the surficial material in the alluvial plains of all rivers and streams of the state. Texture varies widely within very short distances horizontally and vertically, depending on depositional environment. Tough, microscopic clays deposited in quiet water may occur next to coarse sands deposited as a result of levee breaks or deposited by former streams. Most of the alluvial material, however, is silt or sandy silt. Alluvium in the southeastern lowlands is silty and clayey, except on terraces of older alluvium, which tend to be sandy.

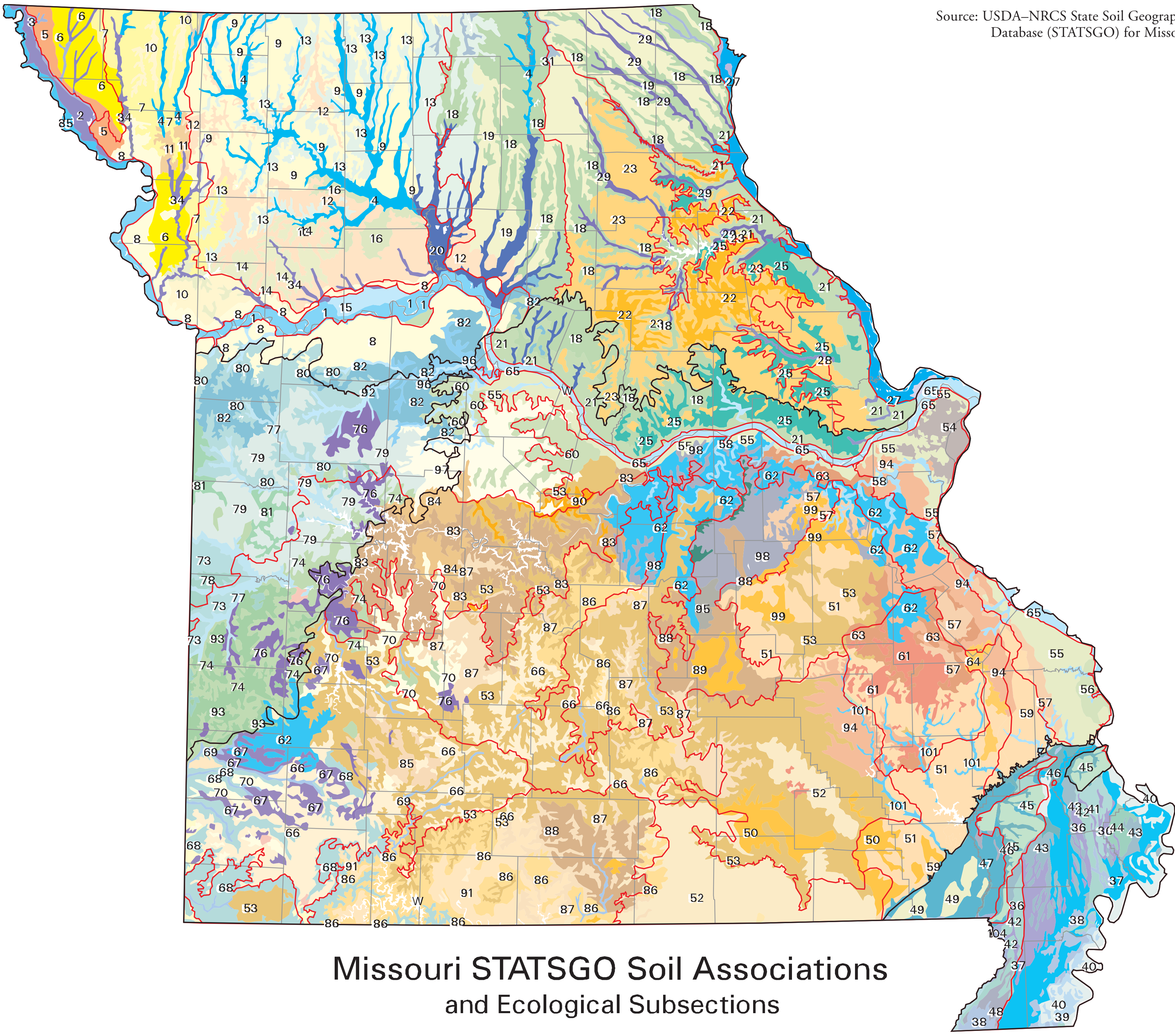
SOILS

The geography of soils in Missouri is complex. Several contrasting soils typically occur within a single hillslope sequence, and even seemingly uniform floodplains have highly variable texture and drainage patterns. However, there are broad regional patterns. The general soil map of Missouri separates the state into 107 different soil associations, each composed of several dominant soil series. From these associations a map was developed of the dominant soil *order* in each general soil map unit. Order is the highest category of the USDA's hierarchical Soil Taxonomy system and reflects regional trends in the soil-forming factors of vegetation, topography, parent material, climate, and time.

Mollisols are dominant in the western part of the Central Dissected Till Plains Section, particularly in the Deep Loess Hills and Loess Hills Subsections, and in the Osage Plains Section. These soils formed under prairie vegetation and have thick, dark surface layers with relatively high levels of soluble bases, such as calcium and magnesium. The mollisols in northwestern Missouri developed in loess of varying thickness and in the underlying glacial till, whereas the Osage Plains mollisols developed in thinner loess and the underlying residuum from sandstone and shale. In the Deep Loess Hills Subsection, most mollisols have silt loam to silty clay loam subsoils, whereas mollisols in other subsections generally have clayey subsoils. Most mollisols have silt loam or loam surface layers.

Alfisols occur throughout Missouri but are particularly dominant in the central and eastern subsections of the Central Dissected Till Plains Section and in the Ozark Highlands Section. These soils formed primarily under deciduous forest or woodland vegetation, although alfisols in the Claypan Till Plains Subsection are thought to have formed under prairie. Alfisols have thin, loamy surface layers, and most have clayey subsoils. Alfisols that formed under savanna or woodland vegetation, and the prairie alfisols of the Claypan Till Plains Subsection have thicker surface layers and are transitional to mollisols. Missouri alfisols are particularly diverse, primarily due to the variety of parent materials and landforms in which they have formed. For example, alfisols on the glacial till backslopes of the Central Dissected Till Plains Section have brown, clay loam and clay subsoils; alfisols on

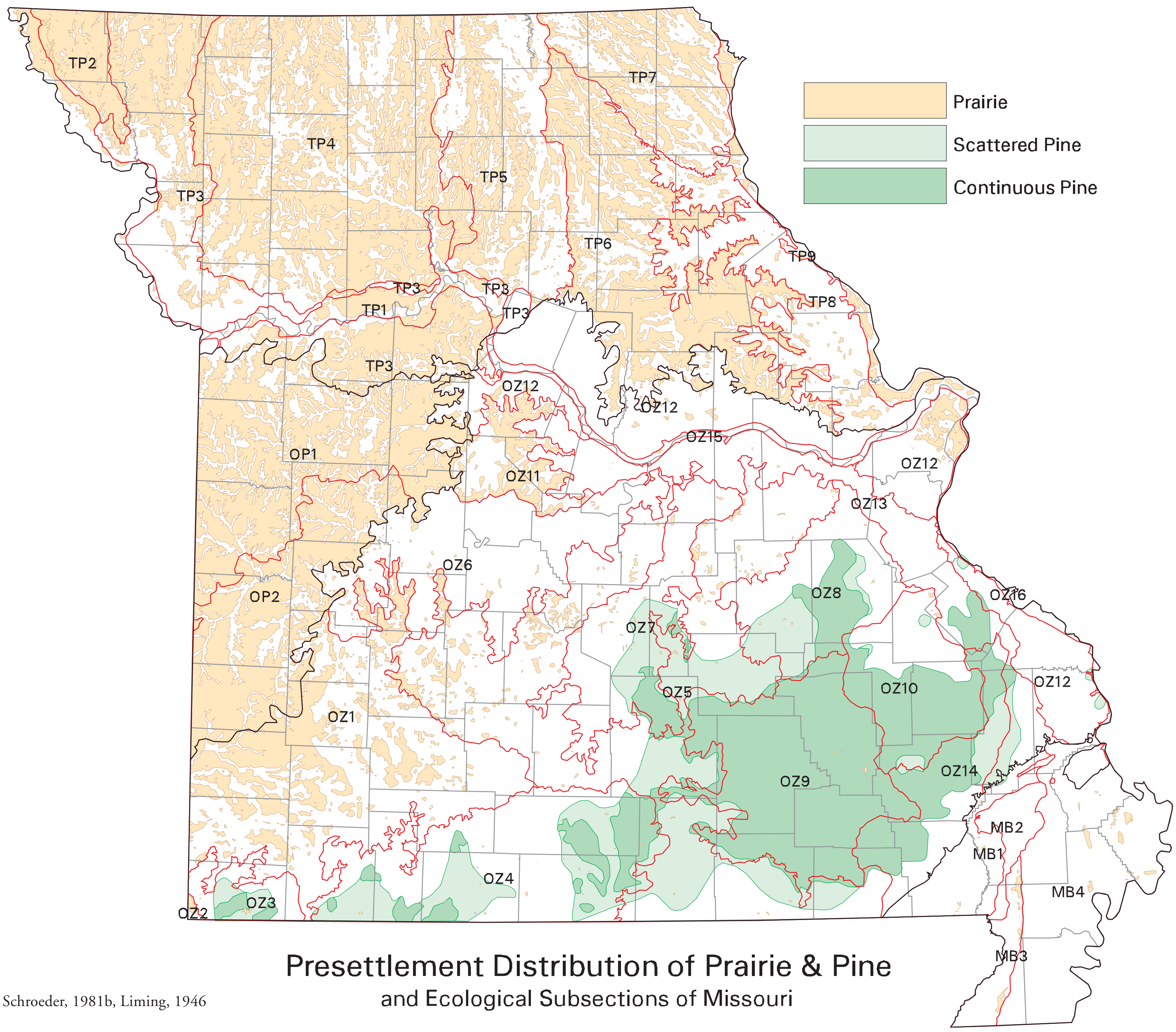
Source: USDA–NRCS State Soil Geographic Database (STATSGO) for Missouri



Missouri STATSGO Soil Associations
and Ecological Subsections

1. Haynie-Leta-Waldron
2. Luton-Salix-Keg
3. Kennebec-McPaul-Nodaway
4. Colo-Nodaway-Zook
5. Monona-Ida-Napier
6. Marshall-Exira-Shelby
7. Sharpsburg-Shelby-Colo
8. Knox-Higginsville-Silbey
9. Lamoni-Shelby-Adair
10. Sharpsburg-Macksburg-Higginsville
11. Gara-Armstrong-Knox
12. Grundy-Lagonda-Lamoni
13. Gara-Armstrong-Pershing
14. Armster-Snead-Ladoga
15. Bremer-Cotter-Booker
16. Greenton-Gosport-Snead
17. Monona-Joy-Winterset
18. Lindley-Keswick-Goss
19. Armstrong-Gara-Adco
20. Carlow-Dockery-Fatima
21. Menfro-Winfield-Weller
22. Mexico-Putnam-Leonard
23. Mexico-Leonard-Armstrong
24. Nodaway-Lawson-Colo
25. Bardley-Gasconade-Cedargap
26. Lomax-Blase-Booker
27. Carlow-Portage-Chequest
28. Haymond-Dockery-Moniteau
29. Fatima-Arbela-Vesser
30. Landes-Sparta-Excello
31. Seymour-Edina-Clarinda
32. Ladoga-Gara-Armstrong
34. Nodaway-Colo-Zook
35. Albaton-Onawa-Haynie
36. Gideon-Sharkey-Sikeston
37. Sharkey-Steele-Tunica
38. Amagon-Dundee-Sharkey
39. Hayti-Portageville-Crevasse
40. Commerce-Sharkey-Fluvaquents
41. Scoto-Clana-Malden
42. Bosket-Malden-Broseley
43. Lilbourn-Wardell-Dundee
44. Scotco-Clana-Malden
45. Memphis-Loring-Falaya
46. Falaya-Adler-Zachary
47. Foley-Jackport-Crowley
48. Dundee-Sharkey-Bosket
49. Tuckerman-Bosket-Amagon
50. Captina-Clarksville-Macedonia
51. Clarksville-Wilderness-Captina
52. Gepp-Doniphan-Agnos
53. Clarksville-Goss-Doniphan
54. Urban Land-Harvester-Fishpot
55. Menfro-Winfield-Haymand
56. Menfro-Clarksville-Haymond
57. Lily-Minnith-Jonca
58. Haymond-Wilbur-Freeburg
59. Loring-Poynor-Weingarten
60. Goss-Pembroke-Union
61. Irondale-Killarney-Delassus
62. Bucklick-Caneyville-Gatewood
63. Crider-Fourche-Bucklick
64. Wilderness-Lebanon-Union
65. Haynie-Waldron-Blake
66. Viration-Scholten-Tonti
67. Hoberg-Keeno-Creldon
68. Clarksville-Noark-Nixa
69. Huntington-Nolin-Peridge
70. Creldon-Gerald-Eldon
71. Eldorado-Newtonia-Wanda
72. Creldon-Parsons-Carytown
73. Parsons-Kenoma-Dennis
74. Barco-Barden-Collinsville
75. Kanima-Parsons-Barden
76. Hector-Bolivar-Mandeville
77. Osage-Verdigris-Lanton
78. Zaar-Lula-Clareson
79. Hartwell-Kenoma-Deepwater
80. Sampsel-Polo-Snead
81. Summit-Eram-Catoosa
82. Macksburg-Marshall-Grundy
83. Bardley-Goss-Gasconade
84. Bardley-Goss-Doniphan
85. Pembroke-Eldon-Creldon
86. Arkana-Moko-Gassville
87. Viration-Clarksville-Lebanon
88. Nixa-Coulstone-Clarksville
89. Lebanon-Yelton-Viburnum
90. Union-Plato-Viration
91. Mano-Ocie-Britwater
92. Dockery-Zook-Blackoar
93. Parsons-Barden-Dennis
94. Hildebrecht-Weingarten-Goss
95. Lebanon-Gatewood-Beemont
96. Pershing-Greenton-Dockery
97. Paintbrush-Maplewood-Friendly
98. Union-Beemont-Hobson
99. Goss-Coulstone-Hobson
100. Glensted-Gerald
101. Midco-Secesh-Viration
102. Clarksville-Nixa-Captina
103. Brockwell-Boden-Portia
104. Falaya-Commerce-Fountain
105. Kobel-Commerce-Dubbs
106. Sharkey-Alligator-Tunica
107. Craig-Eldorado-Dennis

W. Open Water



Presettlement Distribution of Prairie & Pine
and Ecological Subsections of Missouri

Source: Schroeder, 1981b, Liming, 1946

Ozark Highlands hillslopes are formed in residuum from cherty dolomite and have red cherty loam and clay subsoils; and alfisols on many Ozark Highlands ridges have root-restricting fragipans in the subsoil.

Ultisols are prevalent in the Ozark Highlands Section. These soils look similar to alfisols but are very low in soluble bases. Alfisols and ultisols can often be distinguished by the geologic strata from which they formed, with ultisols having formed in strata that have been exposed to weathering and leaching for a longer period of time.

Floodplains in the various alluvial plains subsections are dominated by entisols and, to a lesser extent, inceptisols. The recently deposited alluvial sediments in which entisols form have not developed subsoils. Many retain the textural and color stratification of the original flood-deposited materials. Inceptisols are generally found on more stable, higher positions and have developed soil structure in the subsoil. Soil texture is highly variable among Missouri floodplain entisols, depending on the floodplain landform. For example, soils in splay deposits are typically sandy, soils on natural levees are typically loamy, and back-swamp soils are typically clayey.

HISTORIC VEGETATION

Missouri occupies a central continental position that lies between the great grassland biome to the west and the great forest biome to the east. Thus, during the last few thousand years of postglacial climate fluctuations (which apparently are still continuing), Missouri has experienced the invasion and retreat of different species and plant associations from east and west and from north and south, which has resulted in an extremely rich biological diversity.

Simplistic division of natural vegetation between grassland and forest is not at all adequate for Missouri. Although major portions of Missouri were either pure grassland or completely canopied forest at the beginning of the nineteenth century, it is becoming clear that much, if not most, of Missouri was a complex mixture of grassland(prairie), savanna, woodland and forest. The descriptions of ecoregions in this atlas recognizes these four categories.

Prairies in the early nineteenth century, before extensive Euro-American settlement, or "presettlement" time, occupied about a third of the state. The broadest prairies were in the Osage Plains of west-central Missouri and in the Grand Prairie centering on Audrain County in northeastern Missouri. Prairies occurred both as upland prairies and as wet prairies on the wide alluvial plains along rivers. Elsewhere in northern Missouri, prairies existed in smaller tracts, interlaced with strips of timber in stream valleys and on steeper slopes in tracts of rougher land. The pattern was an intricate geographical mosaic of timber and grass, with exceptional length of "edge," or boundary between the two. The intricate mosaic and associated edge significantly affected the types and numbers of wildlife in presettlement northern Missouri. It appears that just before Euro-American settlement of western and northern Missouri, timber was encroaching on grasslands because Indian use of the land was decreasing and the practice of burning prairies was waning, and because the climate was getting wetter and cooler. The most appropriate terms for these numerous places of tree expansion onto grasslands would be *woodland* and *savanna.* Oak forests occurred in the hills and blufflands along the Missouri and Mississippi Rivers in northern Missouri, except in northwestern Missouri, where midgrass prairies occupied the deep-loess blufflands.

The presettlement vegetation of the Ozarks included true forests, woodland, savanna, and significant prairie tracts. Forests dominated the thoroughly dissected hills of the Current, Black, St. Francis, Meramec, and Gasconade River basins of the eastern Ozarks and the roughest lands of the White and Elk River basins of the southwestern Ozarks. Although oaks dominated these forests, pine was a codominant, especially in the Current and upper Gasconade and Meramec basins, where it also occurred in nearly pure stands generally associated with sandy soils, and in the White and Elk River regions *(see pg. 20)*. Woodland, however, prevailed throughout most of the central and western Ozarks, especially in areas of less relief. In many places it opened into tracts properly called savanna, as in karst uplands in Howell and Laclede Counties. Oaks dominated the Ozark woodlands as well as the forests. Glades, a special vegetative type of cedars and oaks among grasses on thin soil mostly over dolomite, occurred across the Ozarks but were most prevalent in the White River region. Prairies, small in extent but nevertheless true grasslands, occurred in the outer belts of the Ozarks, where they represented lands transitional to the surrounding more extensive prairies. They characterized the smooth uplands of the Springfield Plain and the western Ozarks in general as far north as the Missouri River. They also occurred on the loess-mantled karst plains in counties bordering the Mississippi River, and on the flatter uplands of the eastern Ozarks.

The southeastern lowlands contained what was by far the densest historic forest of Missouri. It had the tallest trees and the greatest variety and produced the greatest biomass. Much of the forest grew in land seasonally or perennially wet and has been termed a "swamp forest," but major areas consisted of upland deciduous forest dominated by oak. Minor areas associated with sandy ridges supported prairie and oak savanna. This region of Missouri contained a substantial number of plants and animals associated with the subtropical forests of the lower Mississippi River valley. Of all the regions of Missouri, the southeastern lowlands has lost the greatest part of its historic vegetative cover. Only a few remnants of the nineteenth-century forest cover remain.

CURRENT LAND COVER

The current land cover of Missouri is the result of several thousand years of both continuous natural processes and human activities. Natural processes include long-term climate change, short-term climate change (e.g., significantly wet or dry years), and climate "disturbances" (e.g., sustained, heavy rains that produce exceptional floods; tornadoes; severe droughts that produce natural fires or explosions of insect populations). However, human activities have changed the vegetative cover more thoroughly geographically and probably more intensively locally, especially since Euro-American settlement. Human activities range from burning grasslands and woodlands over centuries of time and the introduction of "exotic" plants from other continental and foreign locations, to much more obvious activities as conversion of native vegetation to farmlands of crops and pastures and for urban and transportation land uses.

The land-cover map of Missouri shows intense fragmentation of the surface into small tracts *(see pg. 22)*. Striking differences in current land cover are often separated by sharp boundaries commonly associated with land ownership or management. Current land cover is as much the result of division of the land into properties as it is the product of natural environment conditions.

Northern Missouri began to be extensively cleared for farms shortly after statehood in the 1820s in the counties along the Missouri and Mississippi Rivers. Land clearing reached the Iowa line in the 1840s; by the end of the century, most of northern Missouri was in farms, and the rural population was at its historic maximum. In the 1930s, as a result of the Depression, eroded land, farm mechanization, and changes in marketing, farmland began to be abandoned. Marginal cropland became pasture or woodland, and marginal pastures became woodland. Thus the general land cover today, which is a complex mixture of cropland on smoother surfaces and better soils, pasture on irregular surfaces and eroded soils, and woods on steeper slopes and rougher tracts, hides the fact that much more of the land was cropped and severely eroded a century ago. Much of northern Missouri has more land in trees and invasive timber in woodlands than it had a century ago and possibly even in the early nineteenth century, although the pattern is much more fragmented. Native prairies are rare; grasslands are represented by fescue pastures. The blufflands along the Missouri and Mississippi Rivers, and other tracts of rougher land, show up on the land-cover map as "forested," but most is second-growth forest with extensive past grazing influences.

The Osage Plains of west-central Missouri have experienced a similar history of land use. Conversion of the prairies to cropland occurred two or three decades later, generally after the Civil War. In fact, virgin prairies were still being plowed in the 1920s. In the first decades of the twentieth century, land-drainage districts converted many wetlands along streams into cropland. In general, there has been relatively less cropland loss in west-central Missouri in the last half century than in northern Missouri. Thus, the amount of invasive timber in woodlands is less, and the land cover remains more open in pastures and cropland. More native prairie remains in west-central Missouri than anywhere else in the state.

The land cover of the Ozarks shows two distinct subregions. The western Ozarks (except for the Osage basin and the White River country) has considerably more cropland and pasture than the eastern Ozarks, which is more forested. Less-dissected land, somewhat better soils, and natural prairies and woodlands led to a more complete settlement in the western Ozarks, with farms having cropland, pasture, and woodlots. The region around Springfield has the greatest concentration of cattle in Missouri, both dairy and beef cattle. Mainly second growth woodlands and forests dominate the hills and breaks along major rivers of the western Ozarks.

The eastern Ozarks, the Gasconade and Osage river hills, and the White River country are the most thoroughly forested regions of Missouri. However, their forested status today belies the fact that much of their tree cover was cut down during the lumber days of the first decades of the twentieth century or was cleared to establish hill farms. Failure of traditional, subsistence "patch" agriculture in the Ozarks has resulted in the return of much of the farmland to timber or wooded pasture. Cropland and improved pasture exist today basically only in the narrow alluvial bottoms of Ozark streams and flatter uplands. Thus the forest is essentially a second-growth forest, well managed in some areas and unmanaged in most areas. Fire suppression has likely produced a forest that is denser than the woodlands of the early nineteenth century. Extensive efforts over a half century have restored pine to many regions in the eastern Ozarks.

The most thoroughly agricultural region of Missouri is the southeastern lowlands. Almost 95 percent (excluding Crowley's Ridge) is in farms, and almost all of those are in croplands—very little land is in pasture. Remnants of the lowland forest that once covered the region occur in small, managed tracts and in locations without levees to protect them from flooding.

The alluvial plains along the Mississippi and Missouri Rivers stand out on the map of current land cover. Most of the leveed bottomlands are highly productive croplands, although since the Great Flood of 1993, several sizable alluvial tracts have been converted to managed wetlands.

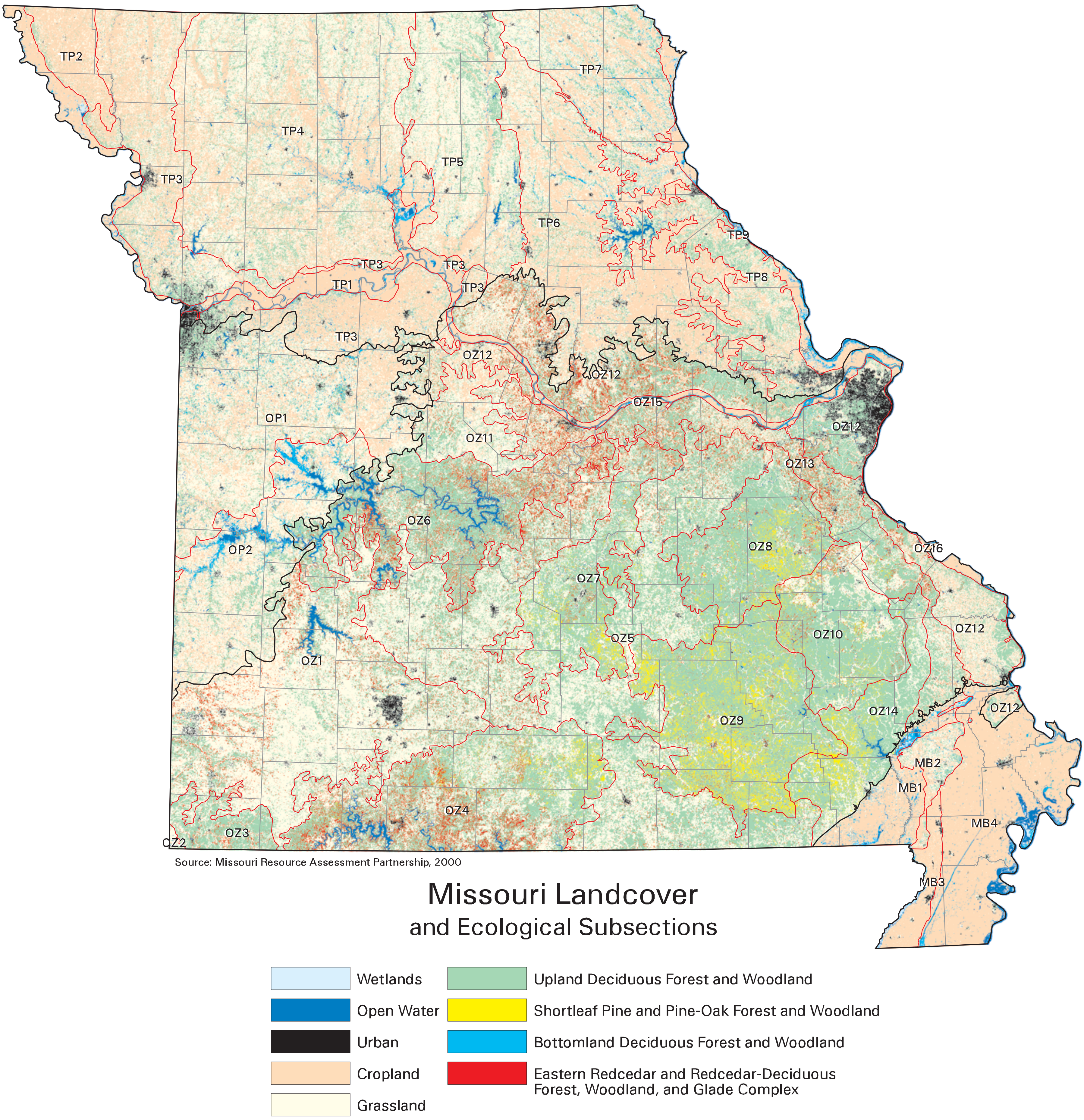
Urban land uses occupy an ever-increasing portion of the surface of Missouri. The urbanized land of the St. Louis and Kansas City metropolitan areas extends into eight and five Missouri counties, respectively. Other officially designated metropolitan areas in Missouri cover eight more counties. Smaller cities and towns cover significant areas, although fragmented and dispersed. The spreading out of urban populations to create lower population densities has the effect of allowing more plant cover within urbanized areas. Most towns and cities, especially in residential areas, have more trees and parkland than in the past, allowing more opportunities for the spread of plants and animals into them. Nevertheless, urbanization changes the landscape in semipermanent ways, such as introducing extensive impermeable surfaces that decrease infiltration of water into the ground and increase runoff, with a resulting degradation of water quality, and in long-term, subtle ways, such as increasing air temperatures and changing the nature of precipitation.

In rural regions, major transportation corridors affect natural processes and invite economic development. Highways serve as corridors for the invasion of exotic species and fragment the natural landscapes.

Large lakes also invite economic development. The Lake of the Ozarks and the Table Rock Lake–Branson areas become the equivalent of small metropolitan areas during summers. Smaller lakes have proportionately smaller developments, but they often occur within otherwise sparsely populated, relatively "natural" areas; thus, seasonal population increases have a noticeable affect on local ecosystems.

Gary Reese

Much of the estimated 200,000 acres of remaining prairie in the Osage Plains owes its survival to their value as prairie hay meadows.



Missouri Landcover and Ecological Subsections

Source: Missouri Resource Assessment Partnership, 2000